See the possibilities

User's Manual

AM-1600GE
AB-1600GE

Digital Monochrome / Color
Progressive Scan GigE Vision Camera

Document Version: Ver.1.0
AMB-1600GE_ver.1.0_Apr09

Notice

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Warranty

For information about the warranty, please contact your factory representative.

Certifications

CE compliance

As defined by the Directive 2004/108/EC of the European Parliament and of the Council, EMC (Electromagnetic compatibility), JAI Ltd., Japan declares that AM-1600GE-P, AM-1600GE-F,AB-1600GE-P and AB-1600GE-F comply with the following provisions applying to its standards.
EN 61000-6-3 (Generic emission standard part 1)
EN 61000-6-2 (Generic immunity standard part 1)

FCC

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into a outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Warning

Changes or modifications to this unit not expressly approved by the party responsible for FCC compliance could void the user's authority to operate the equipment.

Supplement

The following statement is related to the regulation on " Measures for the Administration of the control of Pollution by Electronic Information Products " , known as " China RoHS ". The table shows contained Hazardous Substances in this camera.

mark shows that the environment-friendly use period of contained Hazardous Substances is 15 years.

重要注意事项

有毒，有害物质或元素名称及含量表

根据中华人民共和国信息产业部『电子信息产品污染控制管理办法』，本产品《 有毒，有害物质或元素名称及含量表 》如下.

部件名称	有毒有害物质或元素					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr(VI))	多溴联苯 (PPB)	多溴二苯醚 (PBDE)
螺丝固定座	×	○	○	○	○	○
.....	.....	.....	.....	.....	.....	.....

○: 表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T11363-2006规定的限量要求以下。
×: 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T11363-2006规定的限量要求。
（企业可在此处、根据实际情况对上表中打 " × " 的技术原因进行进一步说明。）

环保使用期限

电子信息产品中含有的有毒有害物质或元素在正常使用的条件下不会发生外泄或突变、电子信息产品用户使用该电子信息产品不会对环境造成严重污染或对基人身、财产造成严重损害的期限。

数字「15」为期限15年。

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螺丝固定座	×	○	○	○	○	○
光学滤色镜	×	○	×	○	○	○
.....	.....	.....	.....	.....	.....	.....

○: 表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T11363-2006规定的限量要求以下。
×: 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T11363-2006规定的限量要求。
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Table of Contents

1. General

The AM-1600GE and AB-1600GE are 16-megapixel, high resolution GigE Vision Compliant cameras for applications such as high density board inspection, flat panel display inspection, and so on. The AM-1600GE is a monochrome progressive scan CCD camera and the AB-1600GE is the equivalent Bayer mosaic progressive scan CCD camera. Both cameras have a 43.3mm diagonal CCD with 16 million pixels resolution and a continuous frame rate of 3.0 frames per second. The AM-1600GE and AB-1600GE support partial scan read out for faster frame rates. The AM-1600GE also has a vertical binning mode for a faster frame rate, as well as higher sensitivity.
The AM-1600GE has internal pre-processing circuits for blemish compensation, shading compensation and a LUT(Look Up Table). Both cameras accept external trigger pulses with EPS ,PWC, Sequential and Frame Delay modes available.
The Gigabit Ethernet digital output is selectable 8 bits,10 bits or 12 bits. Lens mount options include F mount or Universal P mount, which is the factory option.

The AM-1600GE and AB-1600GE also comply with the GenICam standard and contain an internal XML file that is used to describe the functions/features of the camera. For further information about the GigE Vision Standard, please go to www.machinevisiononline.org and about GenICam, please go to www.genicam.org.

As an application programming interface, JAI provides a SDK (Software Development Kit). This SDK includes GigE Vision Filter Driver, JAI Control tool, software documentation and code examples.
The JAI SDK can be downloaded from www.jai.com.

The latest version of this manual can be downloaded from www.jai.com

For camera revision history, please contact your local JAI distributor.

2. Camera nomenclature

The standard camera composition consists of the camera main body and C-mount protection cap.

The camera is available in the following versions:
AM-1600GE-P, AM-1600GE-F
Where **A** stands for "Advanced" family, **M** stands for "Monochrome", **1600** represents the resolution "16 million pixel" and **GE** stands for "GigE Vision" interface. **P** for the Universal P mount version and **F** for the Nikon F mount version.

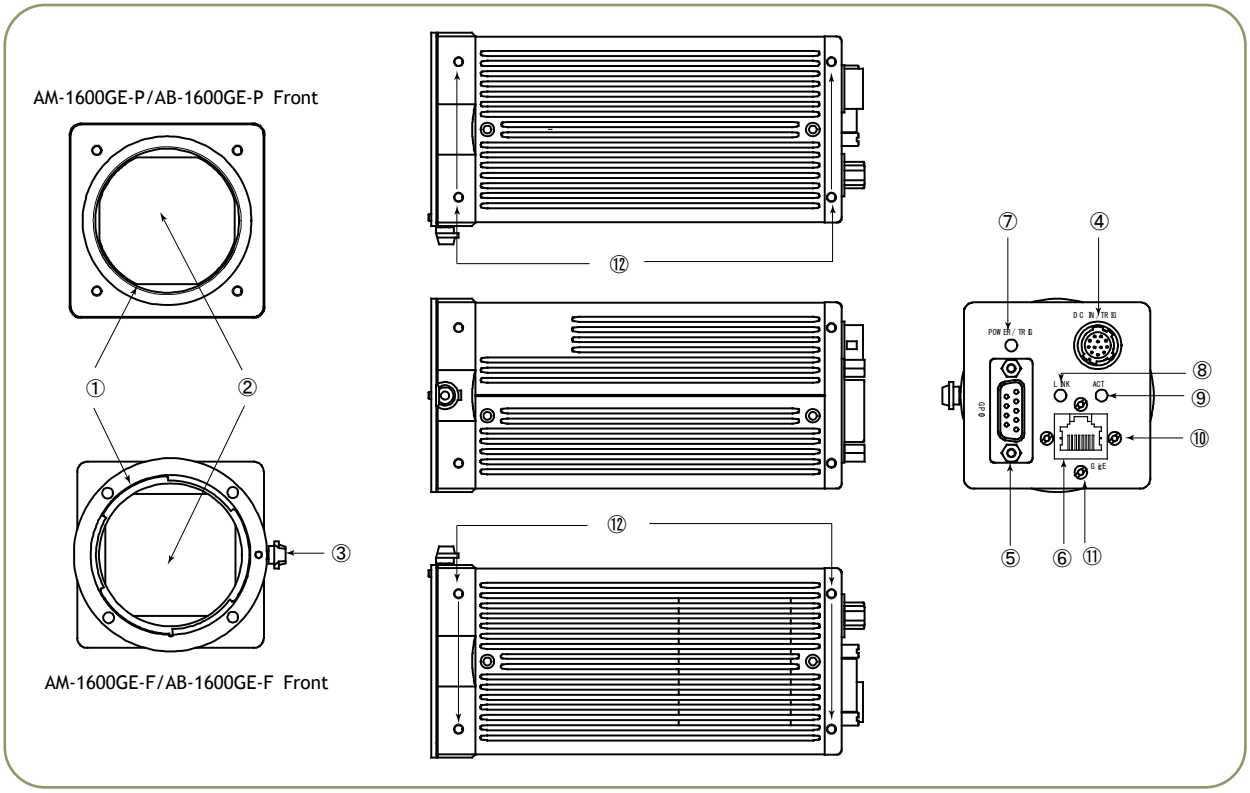
AB-1600GE-P, AB-1600GE-F
Where **A** stands for "Advanced" family, **B** stands for "Bayer mosaic color", **1600** represents the resolution "16 million pixel" and **GE** stands for "GigE Vision" interface. **P** for the Universal P mount version and **F** for the Nikon F mount version.

3. Main Features

- C3 Advanced series progressive scan camera
- GigE vision, GenICam compliant
- Monochrome and Bayer mosaic color versions
- KAI-16000 IT CCD, 43.3mm diagonal (35mm film size)
- 4872 (h) x 3248 (v) active pixels
- 7.4 µm square pixels
- 12- or 10- or 8-bit output
- 16 bits signal processing
- 3 frames/second with full resolution in continuous and triggered operation
- Variable partial scan is available with user-definable height and starting point
- 2X vertical binning mode (AM-1600GE only)
- Programmable shutter from 3 lines(296µs) to 3327 lines (328 ms)
- Edge Pre-select and Pulse Width Control trigger modes
- Sequence trigger mode for on-the –fly change of gain, exposure and ROI
- Built in programmable Look Up Table (LUT) for gamma, 0.45
- Blemish compensation circuit built in(AM-1600GE only)
- Shading compensation(pixel non-uniformity compensation)(AM-1600GE only)
- L/R channel balance
- AGC(Automatic Gain Control) circuit provided
- Built-in test pattern generator
- Exposure time from 1 line(98.66µs) to 2 sec.* using Pulse Width trigger mode
- GPIO in combination with Pulse Width trigger for more precise exposure time
- One-push and manual Bayer white balance (AB-1600GE only)
- Programmable GPIO with opto-isolated inputs and outputs
- Two types of lens mounts available as factory option, Universal P mount or Nikon F mount
- Comprehensive software tools and SDK for Windows XP/Vista (32 bit"x86" and 64 bit "x64" JAI SDK Ver. 1.2.1 and after)

*****For best image quality, the maximum recommended exposure time is <6 frames (2 seconds), however, depending on your application, significantly longer exposure may still produce an acceptable signal-to-noise ratio, even without applying any external cooling.

4. Locations and Functions



①	Lens mount	Universal P mount (Note *1)
①	Lens Mount	Nikon F mount (Note*2)
②	CCD sensor	43.3mm diagonal CCD sensor
③	Lock knob	Lens lock knob for Nikon F mount lens
④	12-pin connector	DC +12V and GPIO interface
⑤	D-sub 9 pin connector	Auxiliary GPIO interface (LVDS IN and TTL IN/OUT)
⑥	RJ-45	GigE Vision I/F. Accepts connector w thumbscrews.
⑦	LED	Indication for Power and trigger inputs
⑧	LED	Indication for GigE Network condition: LINK
⑨	LED	Indication for GigE Network condition: ACT
⑩	Holes for RJ-45 thumbscrews	Horizontal type (above and below RJ-45)(Note*3)
⑪	Holes for RJ-45 thumbscrews	Vertical type (left and right of RJ-45) (Note *3)
⑫	Mounting holes	M3 depth 5 mm for tripod mount plate (Note *4)

*1) Note: Rear protrusion on P-mount lens must be less than 11.0mm.
*2) Note: Rear protrusion on F-mount lens must be less than 12.0mm.
*3) Note: When an RJ-45 cable with thumbscrews is connected to the camera, please do not excessively tighten screws by using a screw driver. The RJ-45 receptacle on the camera might be damaged. For security, the strength to tighten screws is less than 0.147 Newton meter (Nm). Tightening by hand is sufficient in order to achieve this. When D-SUB 9 pin connector is used, use the vertical type.
*4) Note: The tripod adapter plate MP-41 can be used with AM/AB-1600GE

Fig.1 Locations

5. Pin Assignment

5.1 12-pin Multi-connector (DC-in/GPIO/Iris Video)

Type: HR10A-10R-12PB
(Hirose) male.
(Seen from the rear of camera)

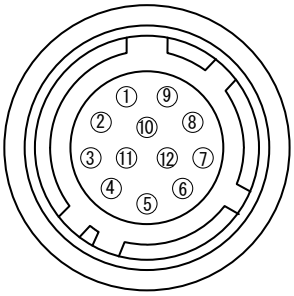


Fig. 2 12-pin connector.

Pin no.	Signal	Remarks
1	GND	
2	+12 V DC input	
3	Opt IN 2 (-) / GND (*1)	GPIO IN / OUT
4	Opt IN 2 (+)/Iris Video out (*1)	
5	Opt IN 1 (-)	
6	Opt IN 1 (+)	
7	Opt Out 1 (-)	
8	Opt Out 1 (+)	
9	Opt Out 2 (-)	
10	Opt Out 2 (+)	
11	+ 12 V DC input	
12	GND	

*1: Iris Video output function can be set by the internal DIP switch (SW601).

5.2 Digital Output Connector for Gigabit Ethernet

Type: RJ-45 : HFJ11-1G02E-L21RL or equivalent

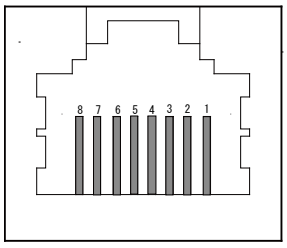
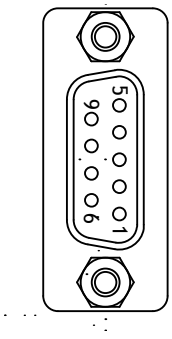


Fig. 3 Gigabit Ethernet connector

The digital output signals follow the Gigabit Ethernet interface using an RJ-45 conforming connector. To the right is a table with the pin assignment for Gigabit Ethernet connector.

Pin No	In/Out	Name
1	In/Out	MX1+ (DA+)
2	In/Out	MX1- (DA-)
3	In/Out	MX2+ (DB+)
4	In/Out	MX3+ (DC+)
5	In/Out	MX3- (DC-)
6	In/Out	MX2- (DB-)
7	In/Out	MX4+ (DD+)
8	In/Out	MX4- (DD-)

5.3 D-sub 9 pin connector for GPIO (Auxiliary)



Type: DD-09SSG

Fig. 4 D-sub 9 pin connector

No	I/O	Name	Note
1	I	LVDS In1-	
2	I	LVDS In1+	
3	I	TTL IN 1	75ohm Terminator *1
4	O	TTL Out 1	
5		GND	
6		NC	
7		NC	
8	O	TTL Out 2	
9		GND	

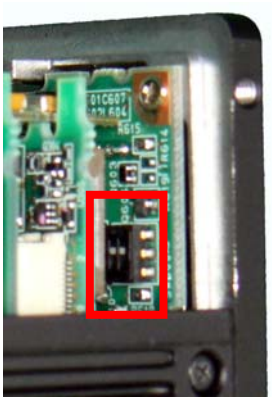
*1: can be changed by DIP SW(SW600).

5.4 Internal DIP switch

In order to change, the top cover must be removed.

SW600 For selection of TTL IN 1 75 ohm ON or OFF

Factory default is UP position (75 ohm OFF). To set 75 ohm ON, these two switches must be DOWN.



Right side, as seen from the lens side

Fig.5 DIP switches

6. GPIO (Inputs and outputs)

6.1 Overview

All input and output signals pass through the GPIO (General Purpose Input and Output) module. The GPIO module consists of a Look-Up Table (LUT – Cross-Point Switch), 2 Pulse Generators and a 12-bit counter. In the LUT, the relationship between inputs, counters and outputs is governed by internal register set-up.

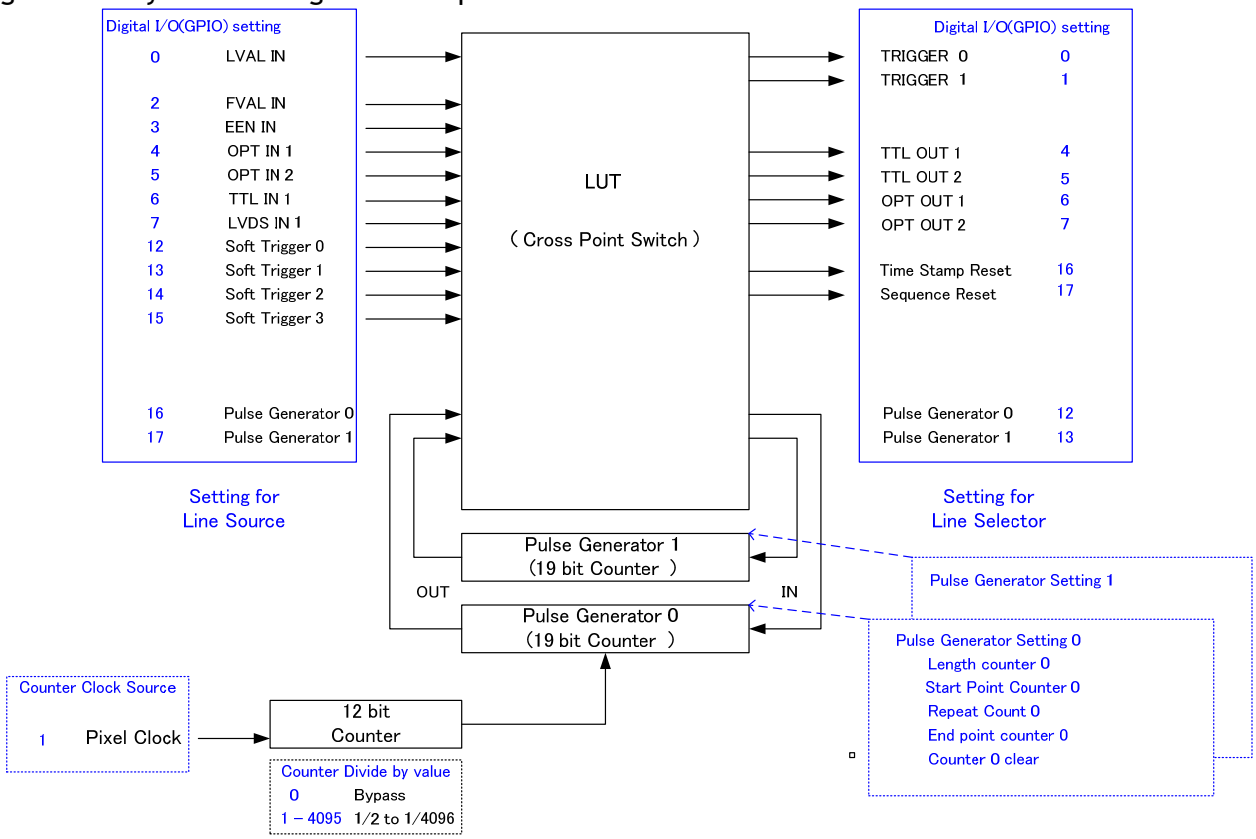


Fig.6 GPIO interface

Some of the descriptions in this diagram differ from those displayed in the camera control tool. The following table shows display names and descriptions.

Line Source		Line Selector	
Description	**Display Name**	Description	**Display Name**
OPT IN 1	Line5-Optical In1	TTL OUT 1	Line1-TTL Out1
OPT IN 2	Line6-Optical In2	TTL OUT 2	Line2-TTL Out2
TTL IN 1	Line7-TTL In	OPT OUT 1	Line3-Optical Out1
LVDS IN 1	Line8-LVDS In	OPT OUT 2	Line4-Optical Out1

The blocks shown in the above diagram have the following functionality:

6.1.1 LUT (Cross Point Switch)

The LUT works as a cross-point switch which allows connecting inputs and outputs freely. The signals LVAL_IN, FVAL_IN and EEN_IN all originate from the camera timing circuit.
On this diagram, “Trigger 0” is used for camera exposure and “Trigger 1” is used for Delayed Readout. The “Time Stamp Reset” signal can reset the time stamp specified in GigE Vision Format. This signal can be used when time stamps from several cameras connected are coincident with each other. The “Sequence reset” resets the sequential settings. Outputs from LUT described on the right side show GPIO settings for LINE SELECTOR in the JAI Camera Control tool and inputs to LUT on the left side show GPIO settings for LINE SOURCE in the JAI Camera Control tool. Refer to Chapter 6.3.

6.1.2 12-bit Counter

A camera pixel clock can be used as a source. The counter has a “Divide by N”, where N has the range 1 through 4096, allowing a wide range of clock frequencies to be programmed. Setting value 0 is bypass, setting value 1 is 1/2 dividing, and setting value 4095 is 1/4096 dividing. As the pixel clocks for the AM-1600GE and AB-1600GE are 30 MHz, the output frequency is varied from 30MHz to 10.135 KHz.

6.1.3 Pulse Generators (0 to 1)

Each pulse generator consists of a 19-bit counter. The behavior of these signals is defined by their pulse width, start point and end point.
The pulse generator signals can be set in either triggered or periodic mode.
In triggered mode, the pulse is triggered by the rising edge, falling edge, high level or low level of the input signal. In periodic mode, the trigger continuously generates a signal that is based on the configured pulse width, starting point and end point.
Each pulse generator operates at the frequency created in the 12-bit counter. As the pixel clock (30 MHz) is used as the main frequency, the frequency of pulse generator is 30MHz to 10.135 KHz.

6.2 Opto-isolated Inputs/Outputs

The control interface of the C3 GigE Vision camera series has opto-isolated inputs and outputs, providing galvanic separation between the camera's inputs/outputs and peripheral equipment. In addition to galvanic separation, the opto-isolated inputs and outputs can cope with a wide range of voltages; the voltage range for inputs is +3.3V to +24V DC whereas outputs will handle +5V to +24V DC.

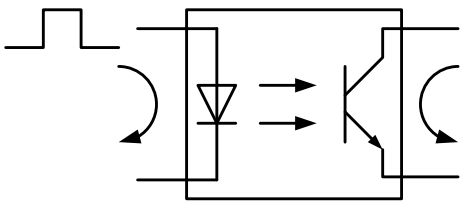


Fig.7 Photo coupler

6.2.1 Recommended External Input circuit diagram for customer

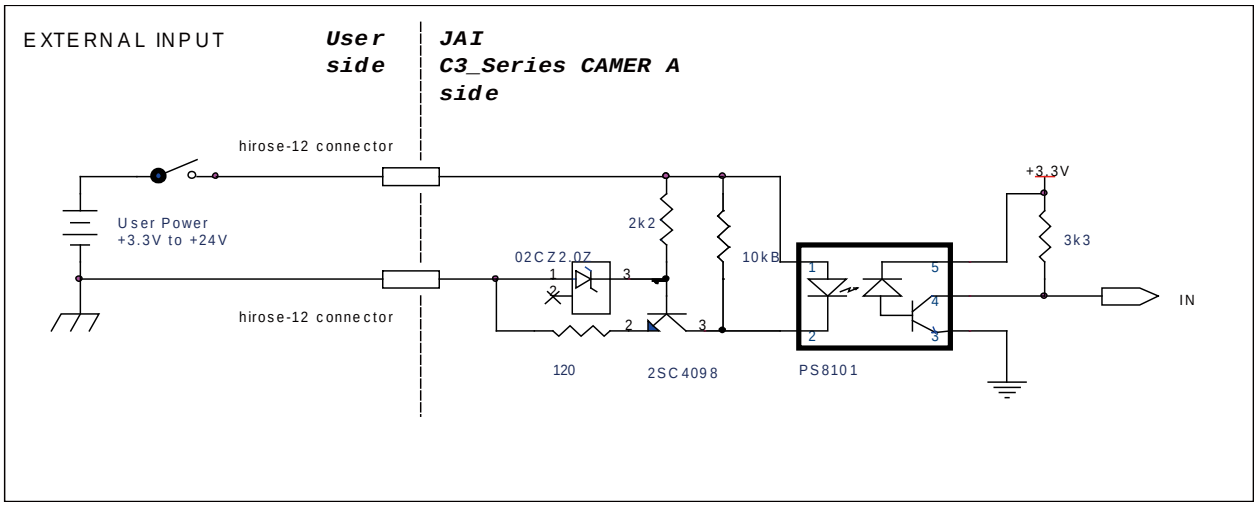


Fig.8 External Input Circuit、OPT IN 1 and 2

6.2.2 Recommended External Output circuit diagram for customer

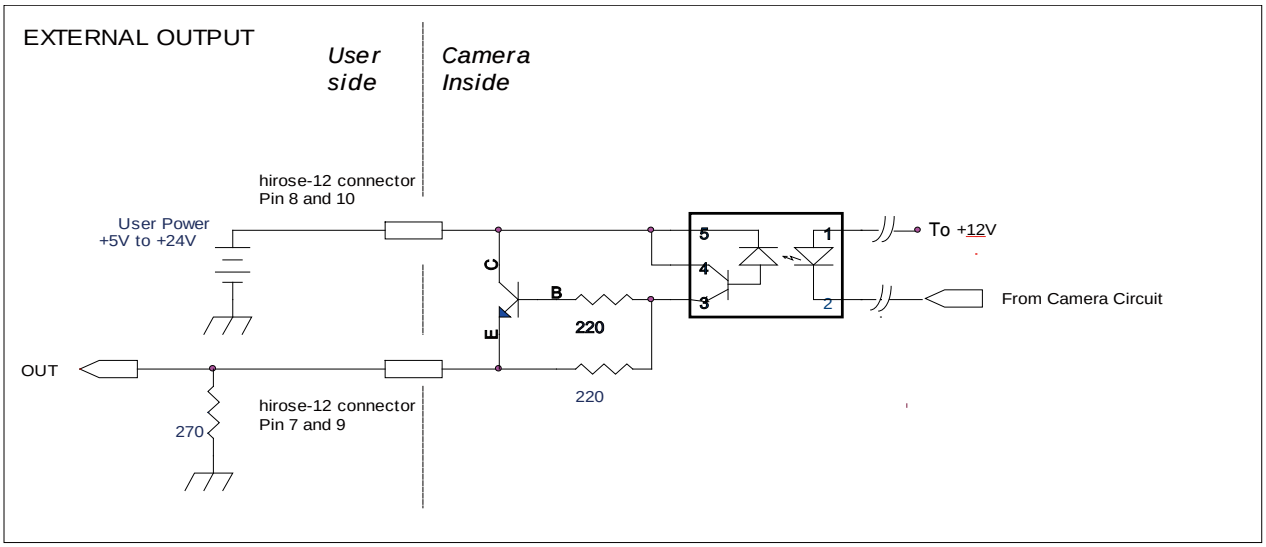
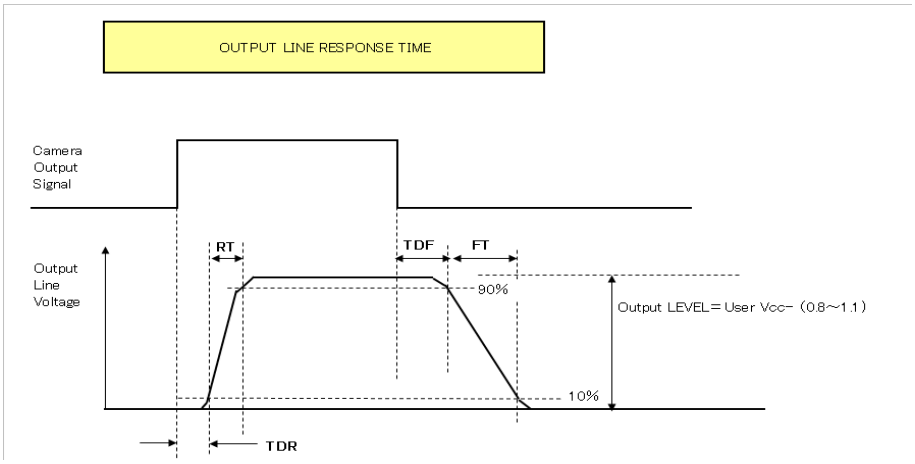


Fig.9 External Output Circuit, OPT OUT 1 and 2

6.2.3 Optical Interface Specifications

The relation of the input signal and the output signal through optical interface is as follows.



Conditions for Input	
Input Line Voltage Range	+3.3V ～ +24V
Input Current	6mA ～ 30mA
Minimum Input Pulse Width to Turn ON	0.5µs

Output Specifications	
Output Load(Maximum Current)	100mA
Minimum Output Pulse Width	20µs
Time Delay Rise TDR	0.5µs ～ 0.7µs
Rise Time RT	1.2µs ～ 3.0µs
Time Delay Fall TDF	1.5µs ～ 3.0µs
Fall Time FT	4.0µs ～ 7.0µs

Fig.10 Optical Interface Performance

6.3. Inputs and outputs table

		Output Ports									
		Trigger 0	Trigger 1	OPT OUT1	OPT OUT2	TTL OUT1	TTL OUT2	Time Stamp Reset	Sequence Reset	Pulse Generator 0	Pulse Generator 1
Input Ports	LVAL IN	×	×	×	×	○	○	×	×	○	○
	FVAL IN	×	×	×	×	○	○	×	×	○	○
	EEN IN	×	×	○	○	○	○	×	×	○	○
	OPT IN 1	○	○	○	○	○	○	○	○	○	○
	OPT IN 2	○	○	○	○	○	○	○	○	○	○
	TTL IN	○	○	○	○	○	○	○	○	○	○
	LVDS IN	○	○	○	○	○	○	○	○	○	○
	Soft Trigger 0	○	○	○	○	○	○	○	○	○	○
	Soft Trigger 1	○	○	○	○	○	○	○	○	○	○
	Soft Trigger 2	○	○	○	○	○	○	○	○	○	○
	Soft Trigger 3	○	○	○	○	○	○	○	○	○	○
	Pulse Gen. 0	○	○	○	○	○	○	○	○	×	○
	Pulse Gen. 1	○	○	○	○	○	○	○	○	○	×

LEGEND: 0 = valid combination / x = Not valid (do not use this combination)
The shaded parts are for the interface to external equipment.

6.4. Configuring the GPIO module (register settings)

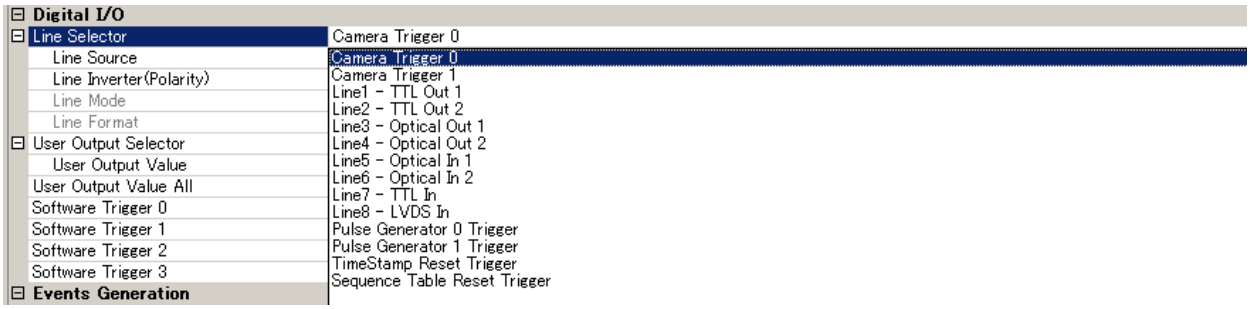
6.4.1 Input/Output Signal Selector

Address	Internal Name	GenICam Name	Access	Size	Value (Range)
0xB060	Selector CAMERA TRIGGER 0 (for Camera Trigger)	Camera Trigger 0	R/W	4	GPIO Selector: **Line Source (SDK)** 0x00:CAMERA LVAL IN 0x02:CAMERA FVAL IN 0x03:CAMERA EEN IN 0x04:OPT 1 IN 0x05:OPT 2 IN
0xB064	Selector CAMERA Trigger 1 (For Delayed Trigger)	Camera Trigger 1	R/W	4	
0xB070	Selector GPIO PORT 1	GPIO_Port1	R/W	4	

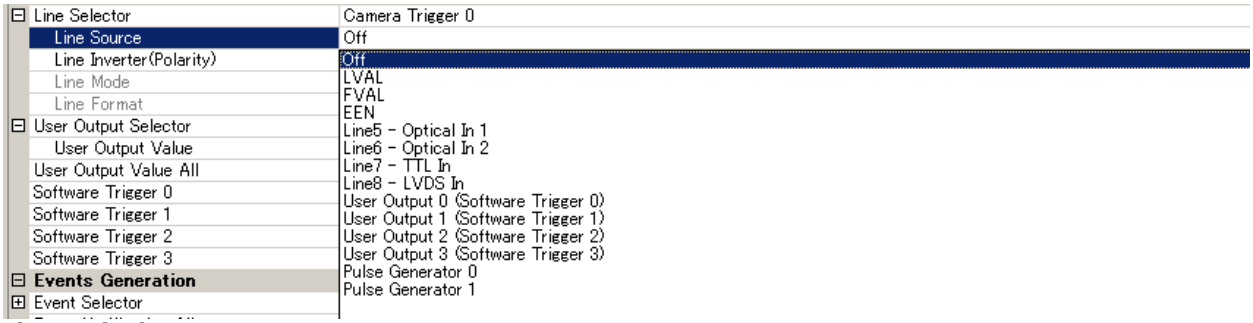
0xB074	Selector GPIO PORT 2	GPIO_Port2	R/W	4	0x06:TTL 1 IN 0x07:LVDS 1 IN 0x0C:USER OUT 0 0x0D:USER OUT 1 0x0E:USER OUT 2 0x0F:USER OUT 3 0x10:Pulse Generator 0 0x11: Pulse Generator 1 0x7F: No connect **Line selector (SDK)** 0x00:CAMERA Trigger 0 0x01:CAMERA Trigger 1 0x04:TTL OUT 1 0x05:TTL OUT 2 0x06:OPT OUT 1 0x07:OPUOUT 2 0x0C:Pulse Generator 0 0x0D:Pulse Generator 1 0x10:Time stamp reset 0x11:Sequence table reset 0x7F: No connect Add 0x80 will result in low active output.
0xB090	Pulse Generator 0 Selector	PulseGenerator 0	R/W	4	
0xB094	Pulse Generator 1 Selector	PulseGenerator 1	R/W	4	
0xB0A0	Selector Time Stamp Reset	TimeStamp Reset	R/W	4	
0xB0A4	Selector Sequence Table Reset	Sequence Table reset	R/W	4	

The following shows the JAI SDK Camera Control Tool for setting GPIO registers.

Line Selector



Line Source



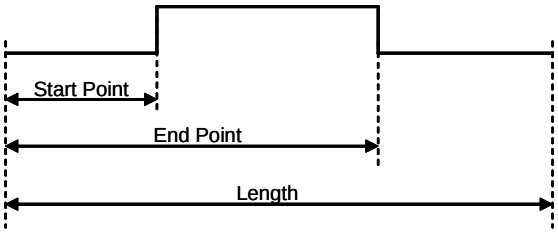
Line Polarity

6.4.2 12bit counter

Address	Internal Name	GenICam Name	Access	Size	Value (Range)
0xB000	Counter Clock Choice	ClockSource	R/W	4	0x01: Pixel Clock
0xB004	Counter Dividing Value	ClockPreScaler	R/W	4	0x000: Bypass 0x001: 1/2 Dividing 0x002: 1/3 Dividing | 0xFFF: 1/4096 Dividing

6.4.3 Pulse generators (19 bit x 2)

There are 2 pulse generators (designated 0 through 1) that can be used to create various timing scenarios by programming start point, endpoint, length and repeats.



The following drawing is an example of settings.
FVAL is used for the input of Pulse Generator 0 and the clock after the rising edge of FVAL counts 100 clocks for the high period of the pulse and 102 clocks for the pulse length.
As 2400 is for Clock Pre-scaler, the output of 12 bit counter is 25 KHz, which is 40µs.
Pulse Generator 0 creates a 4 ms pulse.

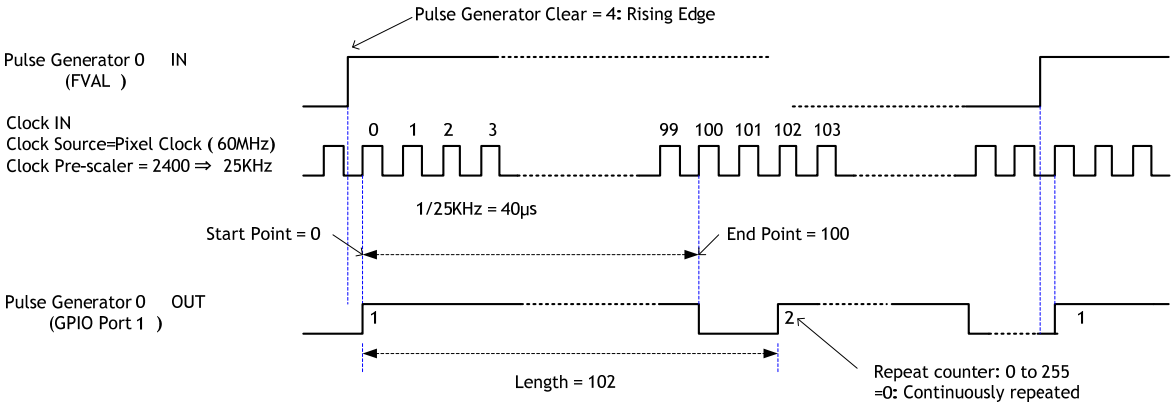
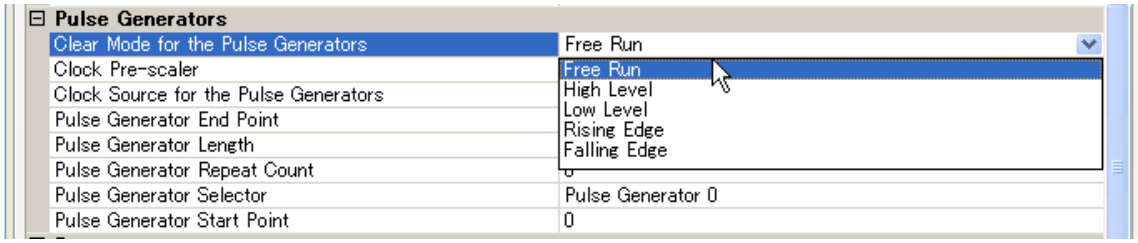


Fig.11 Example of Pulse Generator setting

The following shows JAI SDK Camera Control Tool for setting Pulse Generator.



Address	Internal Name	GenICam name	Access	Size	Value (range)
0xB008	Length Counter 0	Pulse Generator Length	R/W	4	0x00001 to 0xFFFFF
0xB00C	Start point Counter 0(1)	PulseGenerator StartPoint	R/W	4	0x00000 to 0xFFFFF
0xB010	Start point Counter 0(2)	PulseGenerator RepeatCOunt	R/W	4	0x00: infinite 0x01: 1 time | 0xFF: 255 times
0xB014	End point Counter 0	PulseGenerator EndPoint	R/W	4	0x00001 to 0xFFFFF
0xB018	Counter Clear 0	PulseGenerator Clear	R/W	4	0x00: Free Run 0x01: High Level Clear 0x02: Low Level Clear 0x04: Rising Edge Clear 0x08: Falling Edge Clear
0xB01C	Length Counter 1	Pulse Generator Length	R/W	4	0x00001 to 0xFFFFF
0xB020	Start point Counter 1(1)	PulseGenerator StartPoint	R/W	4	0x00000 to 0xFFFFF
0xB024	Start point Counter 1(2)	PulseGenerator RepeatCount	R/W	4	0: Infinite 1: 1 time | 255: 255 times
0xB028	End point Counter 1	PulseGenerator EndPoint	R/W	4	0x00001 to 0xFFFFF
0xB02C	Counter 1 Clear	PulseGenerator Clear	R/W	4	0x00: Free Run 0x01: High Level Clear 0x02: Low Level Clear 0x04: Rising Edge Clear 0x08: Falling Edge Clear

6.5. GPIO programming examples

6.5.1 GPIO Plus PWC shutter

Example: 10µs unit pulse width exposure control (PWC).
Pixel clock is 30MHz. 300 clocks (400-100) equal 10µs.

	Address	Register	Value
	0xA040	Trigger Mode	2 = PWC (Pulse Width Control)
①	0xB090	Pulse Generator 0 Selector	4 =OPT IN 1
②	0xB000	Clock Choice	1 = Pixel Clock (60MHz)
	0xB004	Counter Dividing Value	0 = Pass through
	0xB008	Length Counter 0	1000 Clocks
	0xB00C	Start point Counter 0(1)	100 Clocks
	0xB010	Start point Counter 0(2)	1
	0xB014	End point Counter 0	400 Clocks
	0xB018	Counter Clear 0	4 = Rising Edge Clear
③	0xB060	CAMERA TRIGGER Selector	16 = pulse generator 0
①	0xB090	Pulse Generator 0 Selector	4 =OPT IN 1

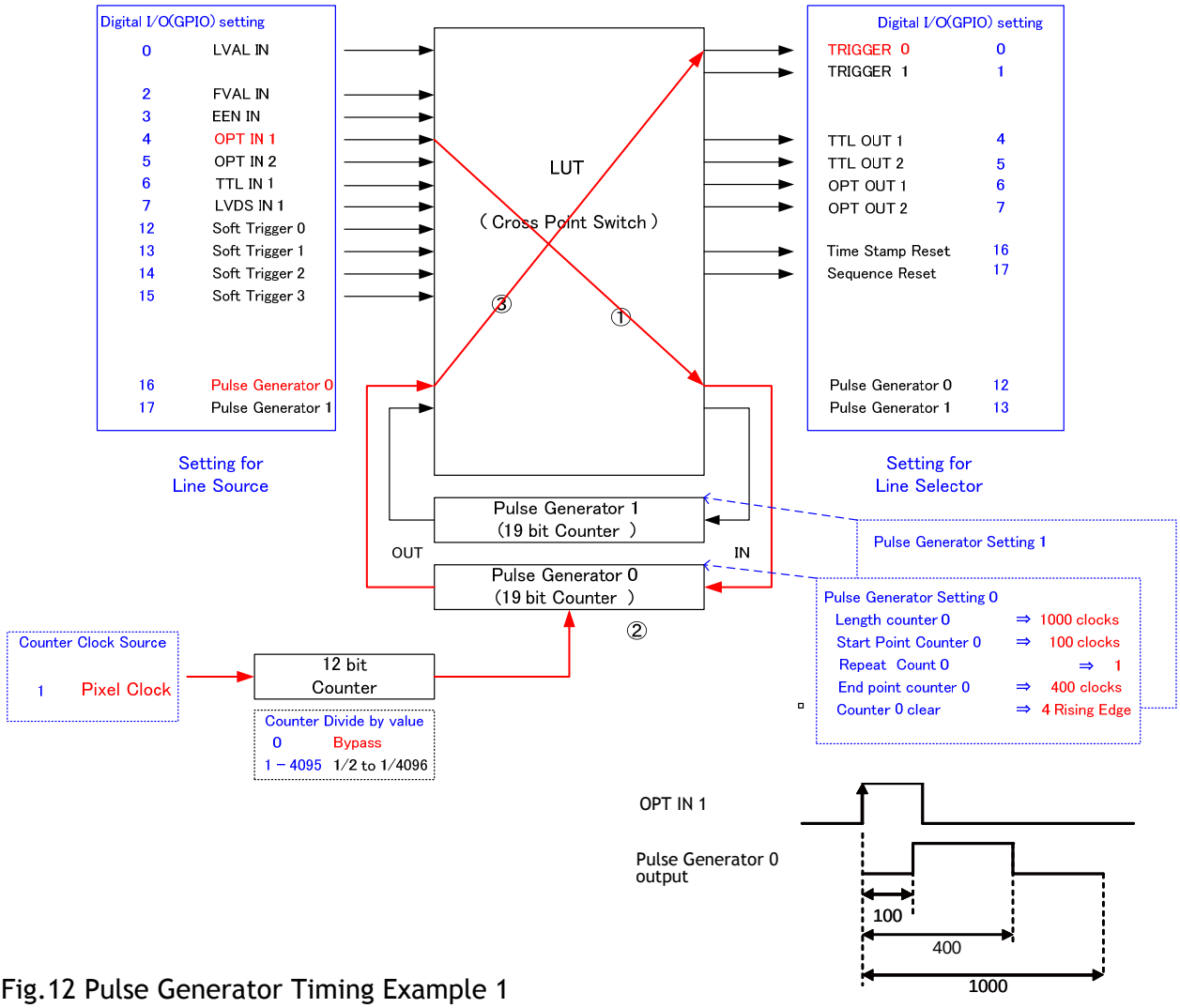


Fig.12 Pulse Generator Timing Example 1

6.5.2 Internal Trigger Generator

Example: Create a trigger signal and trigger the camera

	Address	Register	Value
	0xA040	Trigger Mode	1 = EPS
①	0xB000	Clock Choice	1 = Pixel Clock
	0xB004	Counter Dividing Value	2959 = 1/2960 dev(Line Rate)
	0xB008	Length Counter 0	1000 Clocks
	0xB00C	Start point Counter 0 (1)	100 Clocks
	0xB010	Start point Counter 0 (2)	0 = Infinite
	0xB014	End point Counter 0	500 Clocks
	0xB018	Counter Clear 0	0 = Free Run
②	0xB060	CAMERA TRIGGER Selector	16 = pulse generator 0

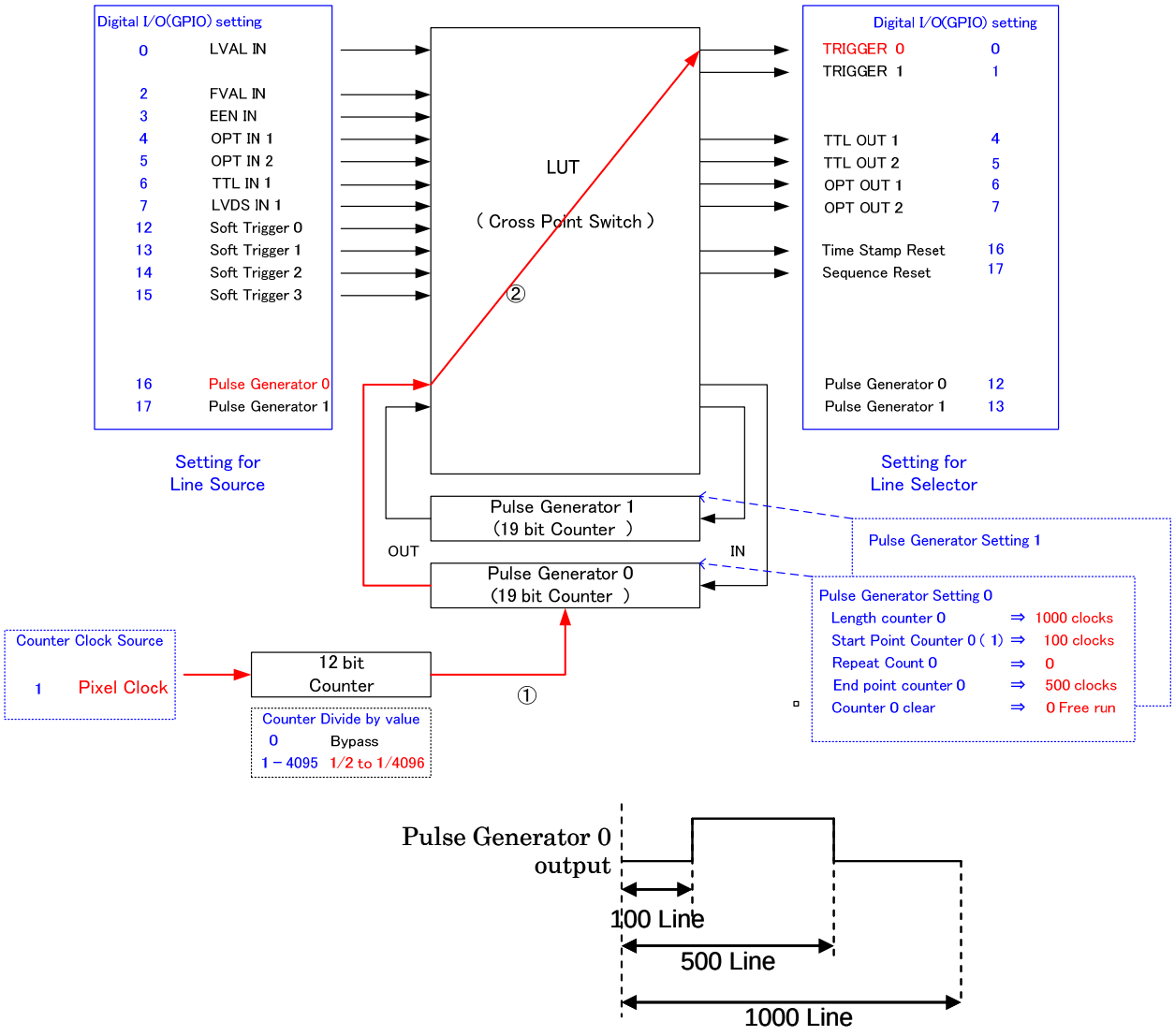


Fig.13 Pulse Generator 0 timing Example 2

7. GigE Vision Streaming Protocol (GVSP)

7.1 Digital Video Output (Bit Allocation)

Although the AM-1600GE and AB-1600GE are digital cameras, the image is generated by an analog component, the CCD sensor.
The table and diagram below show the relationship between the analog CCD output level and the digital output.

CCD out	Analog Signal *	Digital Out		
		8 bit	10 bit	12 bit
Black	Setup 3.6%, 25mV	8 LSB	32 LSB	128 LSB
400mV	700mV	222 LSB	890 LSB	3560 LSB
460mV	800mV	255 LSB	1023 LSB	4095 LSB

The 10-bit digital output is set at 890 LSB as 100% video level when CCD output is 200mV. The white clip level is set at 1023 LSB when CCD output is 230mV.

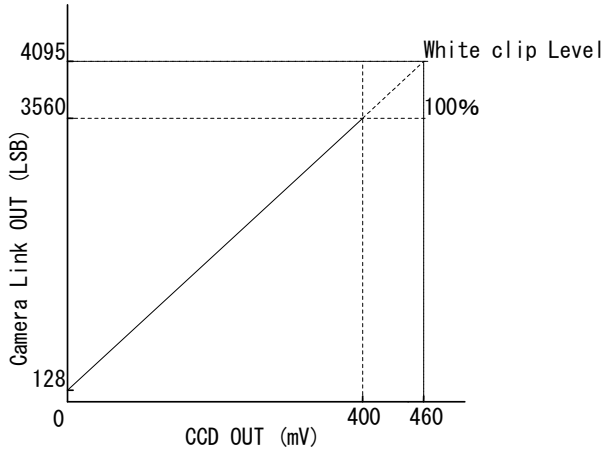


Fig.14 Digital Output

7.2 Bit Allocation (Pixel Format / Pixel Type) – AM-1600GE (monochrome)

In the GigE Vision Interface, GVSP (GigE Vision Streaming Protocol) is used for an application layer protocol relying on the UDP transport layer protocol. It allows an application to receive image data, image information and other information from a device.
In AM-1600GE, the following pixel types supported by GVSP are available.
With regard to the details of GVSP, please refer to GigE Vision Specification available from AIA (www.machinevisiononline.org).

7.2.1 GVSP_PIX_MONO8 (8bit)

1 Byte								2 Byte								3 Byte							
Y0								Y1								Y2							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7

7.2.2 GVSP_PIX_MONO10 (10bit)

1 Byte								2 Byte								3 Byte								4 Byte							
Y0								Y0								Y1								Y1							
0	1	2	3	4	5	6	7	8	9	X	X	X	X	X	X	0	1	2	3	4	5	6	7	8	9	X	X	X	X	X	X

7.2.3 GVSP_PIX_MONO10_PACKED (10 bit)

1 Byte 2 Byte 3 Byte 4 Byte

Y0											Y1										Y2										Y3									
2	3	4	5	6	7	8	9	0	1	X	X	0	1	X	X	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9	0	1	X	X	0	1	X	X	2	3	4	5	6	7	8	9

7.2.4 GVSP_PIX_MONO12 (12 bit)

1 Byte 2 Byte 3 Byte 4 Byte

Y0								Y0								Y1								Y1							
0	1	2	3	4	5	6	7	8	9	10	11	X	X	X	X	0	1	2	3	4	5	6	7	8	9	10	11	X	X	X	X

7.2.5 GVSP_PIX_MONO12_PACKED (12 bit)

1 Byte 2 Byte 3 Byte 4 Byte

Y0												Y1												Y2												Y3											
4	5	6	7	8	9	10	11	0	1	2	3	0	1	2	3	4	5	6	7	8	9	10	11	4	5	6	7	8	9	10	11	0	1	2	3	0	1	2	3	4	5	6	7	8	9	10	11

Address	Internal Name	Access	Size	Value
0xA410	Pixel Format type	R/W	4	0x01080001:Mono8 0x01100003:Mono10 0x010C0004:Mono10 Packed 0x01100005:Mono12 0x010C0006:Mono12 Packed

7.3 Bit Allocation (Pixel Format / Pixel Type) – AB-1600GE (Bayer mosaic color)

In the GigE Vision Interface, GVSP (GigE Vision Streaming Protocol) is used for an application layer protocol relying on the UDP transport layer protocol. It allows an application to receive image data, image information and other information from a device.
In AB-1600GE, the following pixel types supported by GVSP are available.
With regard to the details of GVSP, please refer GigE Vision Specification available from AIA.

7.3.1 GVSP_PIX_BAYGR8 " Bayer GR8 "

Odd line

1Byte 2Byte 3Byte

G0								R1								G2							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7

Even line

B0								G1								B2							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7

7.3.2 GVSP_PIX_BAYGR10 "Bayer GR10"

Odd line

1Byte 2Byte 3Byte 4Byte

G0								G0								R1								R1							
0	1	2	3	4	5	6	7	8	9	X	X	X	X	X	X	0	1	2	3	4	5	6	7	8	9	X	X	X	X	X	X

Even line

B0								B0								G1								G1							
0	1	2	3	4	5	6	7	8	9	X	X	X	X	X	X	0	1	2	3	4	5	6	7	8	9	X	X	X	X	X	X

7.3.3 GVSP_PIX_BAYGR12 " Bayer GR12"

Odd line

1Byte								2Byte								3Byte								4Byte							
G0								G0								R1								R1							
0	1	2	3	4	5	6	7	8	9	10	11	X	X	X	X	0	1	2	3	4	5	6	7	8	9	10	11	X	X	X	X

Even line

B0								B0								G1								G1							
0	1	2	3	4	5	6	7	8	9	10	11	X	X	X	X	0	1	2	3	4	5	6	7	8	9	10	11	X	X	X	X

Address	Internal Name	Access	Size	Value
0xA410	Pixel Format type	R/W	4	0x01080008:BAYGR8 0x0110000C:BAYGR10 0x01100010:BAYGR12

Note 1: AB-1600GE is set at the maximum area when the Bayer sequence starts at GR. Therefore, comparing full scanning and partial scanning, the center might be shifted.

8. Functions and Operations

8.1 GigE Vision Standard Interface

The AM-1600GE and AB-1600GE are designed in accordance with the GigE Vision standard. Digital images are transmitted over Cat5e or Cat6 Ethernet cables. All camera functions are also controlled via the GigE Vision interface.

The camera can operate in continuous mode, providing an endless stream of images. For capturing individual images related to a specific event, the camera can also be triggered. For precise triggering, it is recommended to use a hardware trigger applied to the Hirose 12-pin connector. It is also possible to initiate a software trigger through the GigE Vision interface. However, when using a software trigger, certain latency inherent to the GigE interface must be expected. This latency, which manifests itself as jitter, greatly depends on the general conditions and traffic on the GigE connection. The frame rate described in this manual is for the ideal case and may deteriorate depending on conditions.

When using multiple cameras (going through a switch and/or a single path) or when operating in a system with limited transmission bandwidth the Delayed Readout Mode and Inter-Packet Delay functions can be useful.

8.2 Recommended Network Configurations

Although the AM-1600GE and AB-1600GE conform to Gigabit Ethernet (IEEE 802.3), not all combinations of network interface cards (NICs) and Switches/Routers are suitable for use with the GigE Vision compliant camera.
JAI will endeavor to continuously verify these combinations, in order to give users the widest choice of GigE components for their system design.

8.2.1 Verified Network Interface Cards (NICs)

At the time of publishing this document, the following combinations have been verified:

NIC manufacturer	Model	PCI Bus	PCI-X Bus	PCI-Express Bus
Intel	PRO/1000MT (PWLA8490MT)	√ (33MHz)	√(100MHz)	–
Intel	PRO/1000GT (PWLA8391GT)	√ (33MHz)	√ (33MHz)	–
Intel	PRO/1000PT (EXPI9300PT)	–	–	√ (x1)
Intel	Gigabit CT Desktop adaptor (EXPI9301CT)	–	–	√ (x1)
Intel	PRO/1000PT Quad port (EXPI9404PT)	–	–	√ (x4)
Intel	PRO/1000PT Dual port (EXPI9402PT)	–	–	√ (x4)

Minimum PC requirements are as follows in order to fulfill the above conditions:

- Intel Core 2 Duo , 2.4GHz or better / for AB-1600GE, Core 2 Extreme or better for AB-1600GE
- At least 2 GB memory
- Video Card with PCI Express Bus x 16, VRAM better than DDR2 with 256 MB or more, and display capability of 2560 x 1600
- Windows XP, SP2 (32bit)
- Functions such as Screen saver and Power save should not be used. Unnecessary applications such as Word, Excel or others should not be used.

Note: Pentium 4 type PC is not recommended due to dependency on chip set bus performance.

8.2.2 Video data rate (network bandwidth)

The video bit rate for AM-1600GE and AB-1600GE at the continuous mode is:

Model	Pixel Type	Frame Rate	Packet data volume (for a Packet size of 4040)
AM-1600GE	MONO8	3.04 fps	390 Mbit/s
	MONO10_PACKED MONO12_PACKED	3.04 fps	585 Mbit/s
	MONO10 MONO12	3.04 fps	780 Mbit/s
AB-1600GE	BAYGR8,	3.04 fps	390 Mbit/s
	BAYGR10,BAYGR12	3.04 fps	780 Mbit/s

Note: The above data assumes that OB transfer mode is OFF.

- If using 16KB Jumbo Frames, the packet data will be improved by a maximum of 1 % except Mono8, BAY8.

To ensure the integrity of packets transmitted from the camera it is recommended that users follow these simple guidelines:

1. Whenever possible use a peer-to-peer network.
2. When connecting several cameras, going through a network switch, make sure it is capable of handling jumbo packets and that it has sufficient memory capacity.
3. Configure inter-packet delay to avoid congestion in networks switches.
4. Disable screen saver and power save functions on computers.
5. Use high performance computers with multi-CPU, hyper-thread and 64-bit CPU, etc.
6. Only use Gigabit Ethernet equipment and components together with the camera.
7. Use at least Cat5e and preferably Cat6 Ethernet cables.
8. Whenever possible, limit the camera output to 8-bit.

◆ **Note for setting packet size**

The packet size is set to 1476 as factory default. Packet size can be modified in the GigE Vision Transport layer Control section of the camera control tool. For AM-1600GE and AB-1600GE, users may enter any value for the packet size and the value will be internally adjusted to an appropriate, legal value that complies with the GenICam standard. Thus, the actual packet size may be different than the value entered by user.
Regarding the data transfer rate, a larger packet size produces a slightly lower data transfer rate. The AM-1600GE and AB-1600GE can support a maximum packet size of 16020 bytes if the used NIC has a Jumbo Frames function with setting of 16020 bytes or higher.
The following table shows the list for packet size setting step.

◆ **Note for calculation of Data Transfer Rate**

Setting parameter

Item	Unit	Symbol
Image Width	[pixels]	A
Image Height	[pixels]	B
Bits per Pixel	[bits]	C
Frame Rate	[fps]	D
Packet Size	[Bytes]	E
Number of Packets (including Data Leader & Trailer Packet)	[packets]	G
Data Transfer Rate	[Mbit/s]	J

Fixed value

Item	Unit	value
Data Leader Packet Size	[Bytes]	90
Data Trailer Packet Size	[Bytes]	62

Formula to calculate Data Transfer Rate

$$J = \{90+62+(E+18)*(G-2)\}*8*D/1000000$$

Where,

$$G = ROUNDUP\{A*B*C/8/(E-36)\}+2$$

The following table shows Bits per Pixel (C) which depends on the pixel format.

Pixel format	Bit
MONO8	8
MONO10	16
MONO10Packed	12
MONO12	16
MONO12Packed	12
BAYGR8	8
BAYGR10	16
BAYGR12	16

Calculation example: AM-1600GE Pixel type Mono8

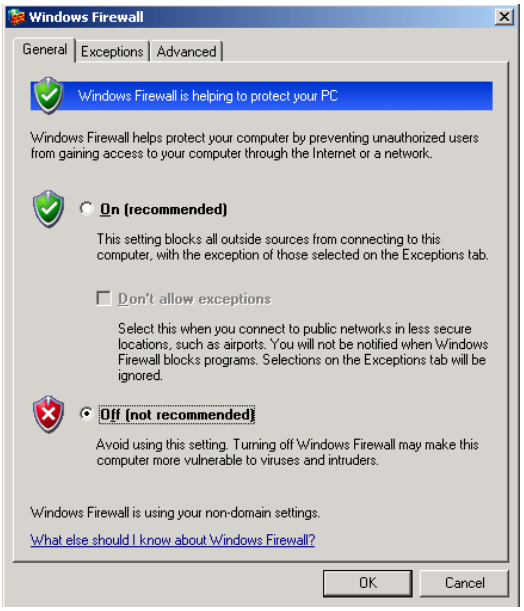
Item	Unit	Symbol	Setting
Image Width	[pixels]	A	4872
Image Height	[pixels]	B	3248
Bits per Pixel	[bits]	C	8
Frame Rate	[fps]	D	3.04
Packet Size	[Bytes]	E	4040
Number of Packets (including Data Leader & Trailer Packet)	[packets]	G	
Transfer Data Rate	[Mbit/s]	J	

G=ROUNDUP {(4872 x 3248 x 8 / 8 / (4040-36)) + 2 = 3953 + 2 = 3955
J={90+62+(4040+18)x(3955-2)} x 8 x 3.04 / 1000000 = **390 Mbit/s**

8.2.3 Disable Firewalls

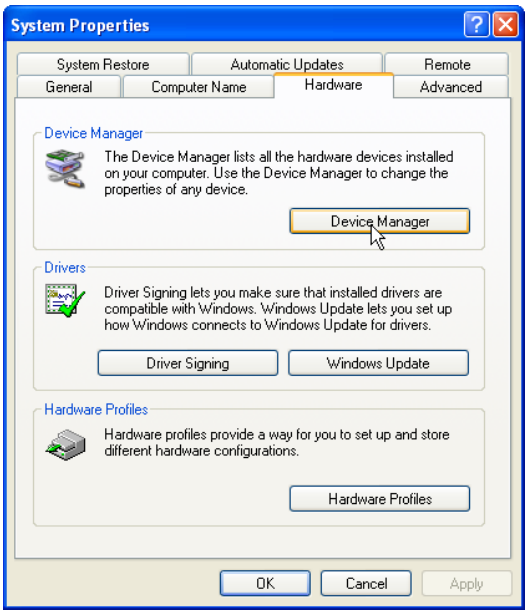
To ensure proper functions of the JAI SDK & Control Tool, all firewalls must be disabled. This also includes the Windows firewall.

Click [**Start**], [**Control Panel**] for accessing the Windows firewall configuration.

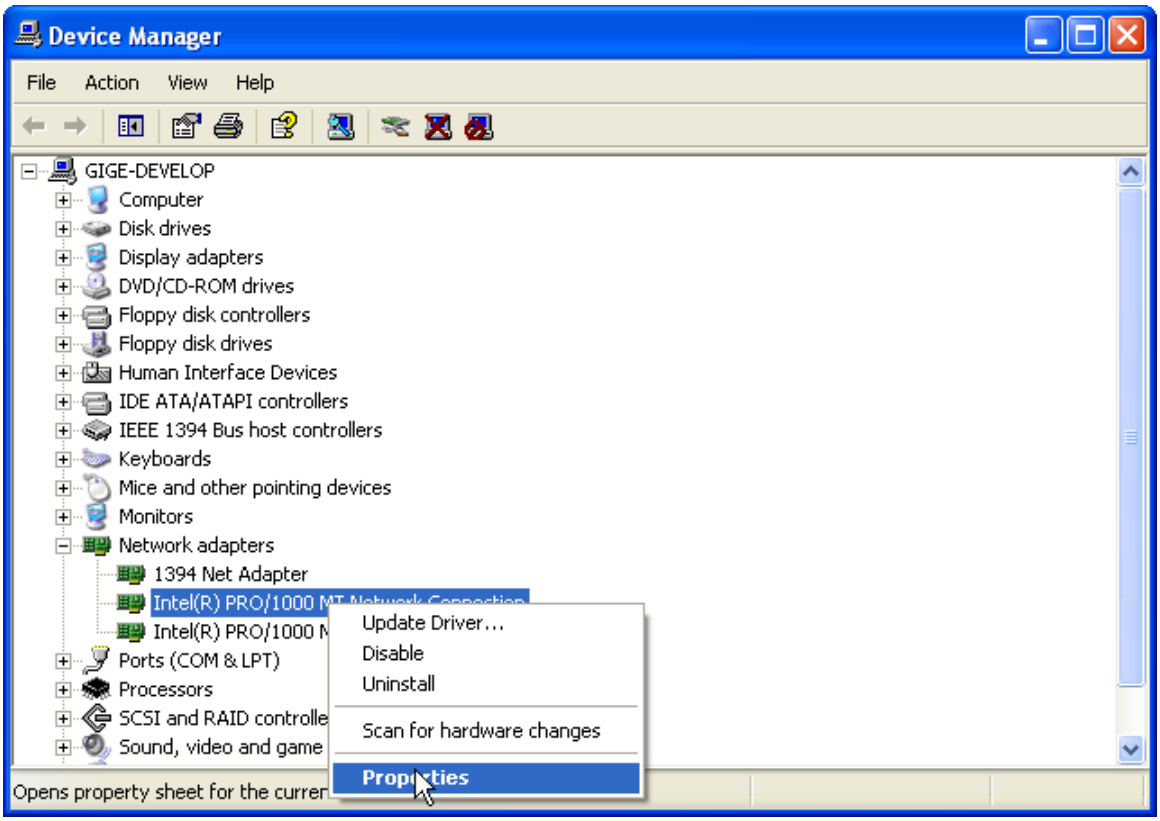


8.2.4 Enabling Jumbo Frames

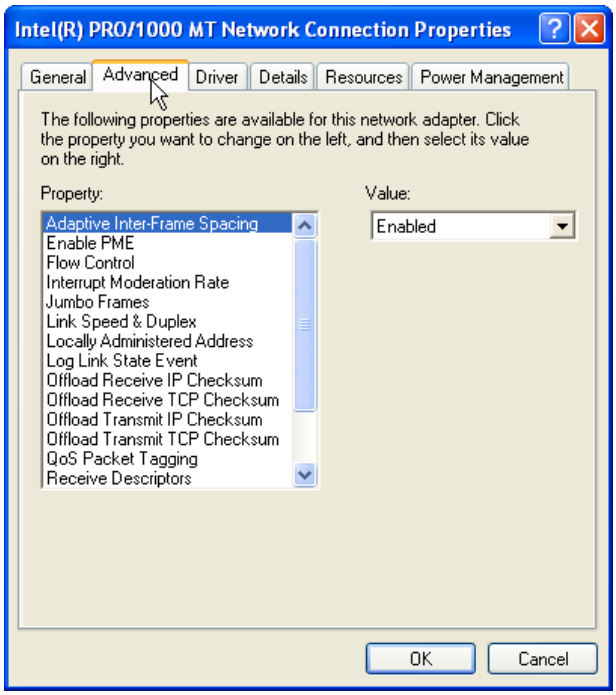
(1) Click [**Start**] and click [**Control Panel**].
(2) Click [**Performance and Maintenance**].
(3) Click [**System**].
(4) Click [**Hardware**] tab.
(5) Click [**Device Manager**].



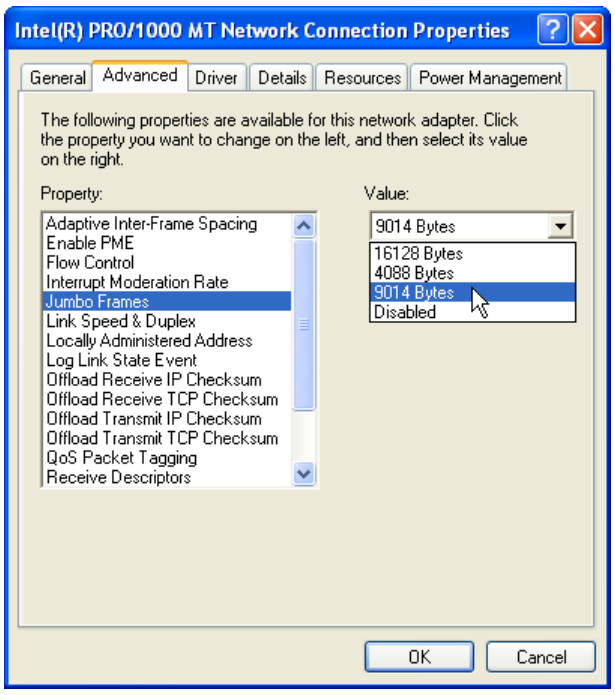
(6) Expand [**Network adapters**].
(7) Select target NIC, **right-click**, and click [**Properties**].



Note: The following procedure uses Intel(R) 1000 NIC as an example.
If a different NIC is used, the setup tabs will likely be different from those shown here.
Follow the tabs associated with the specific NIC used.
(8)Click [**Advanced**] tab.



(9) Select the **Jumbo Frames** of Property, and select **16128** under Value.

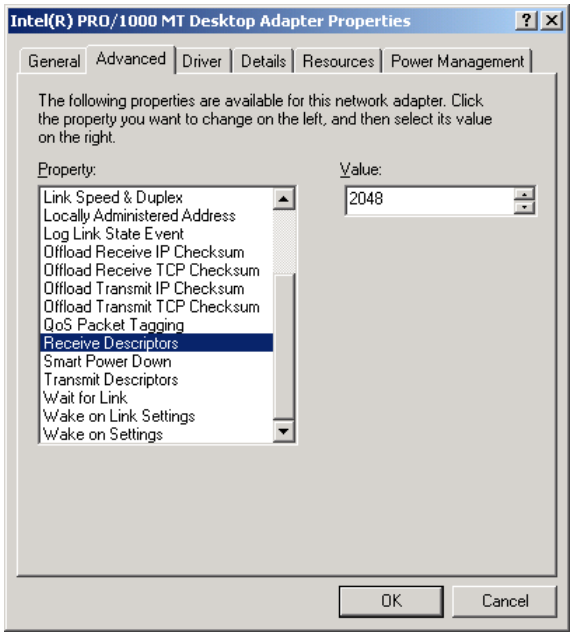


(10)Click [**OK**].
(11)Close [**Device Manager**].
(12)Close [**System Properties**] by clicking [**OK**].

8.2.5 Setting Receive Descriptors

If the Network Connection Properties list contains a property called Receive Descriptors, then change its property to the maximum value supported by the NIC installed in the computer.

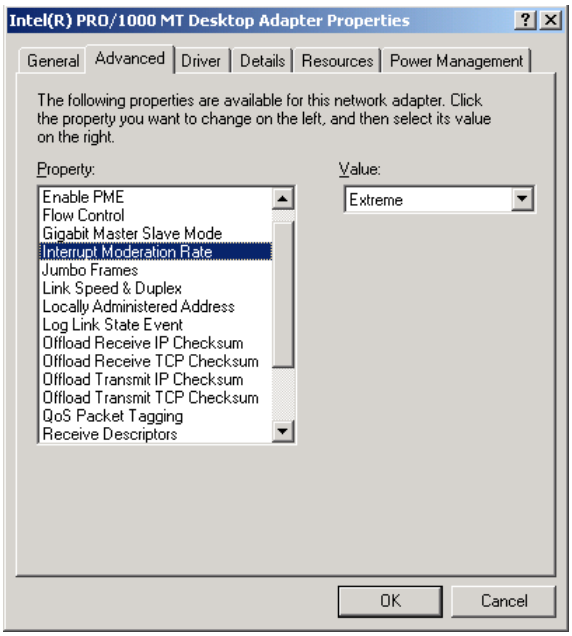
Click “OK” to save the property.



8.2.6 Interrupt Moderation rate

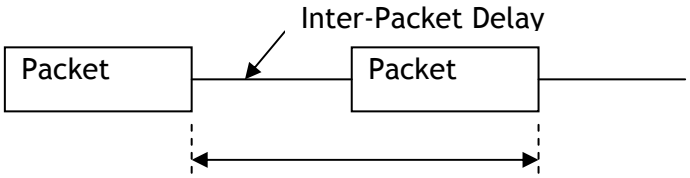
If the Network Connection Properties list contains a property called Interrupt Moderation Rate, then it is possible to set the preferred value. When it is changed from Minimal, Medium, High and Extreme, number of interruption is decreased to get better performance. Set it to "Extreme".

Click "OK" to save the property.



8.2.7 Calculating and setting Inter-Packet Delay

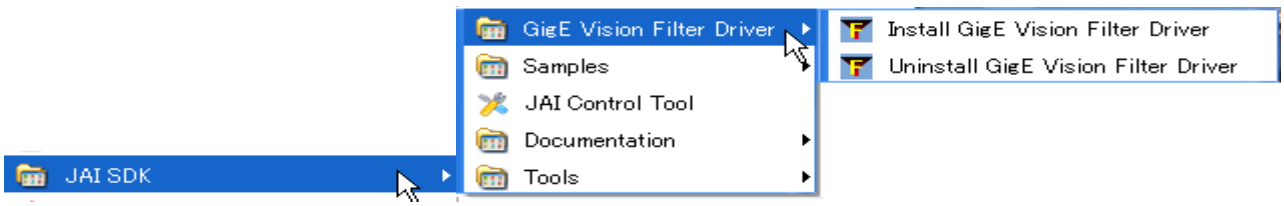
When connecting several cameras to one network interface card via a switching hub, it is important to optimize the Inter-Packet Delay of the cameras to avoid congestion in the switch. A sure sign of congestion is the loss of packets.
Since increasing the inter-packet delay also adds overhead to the data transfer it is important to calculate the optimal setting in order to make best use of the video bandwidth.



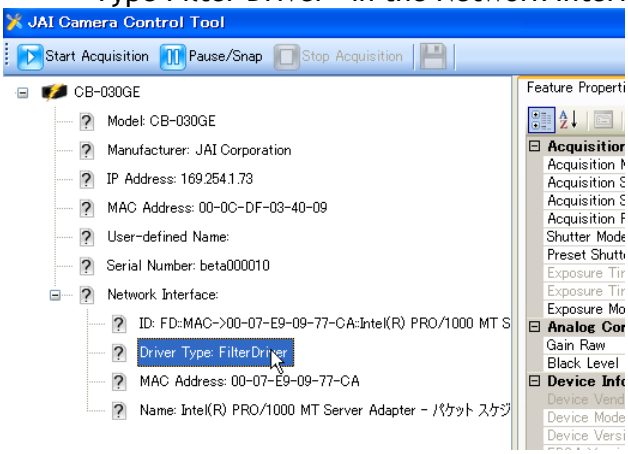
Duration of the entire packet, with delay

8.2.8 Confirm the Filter Driver is used

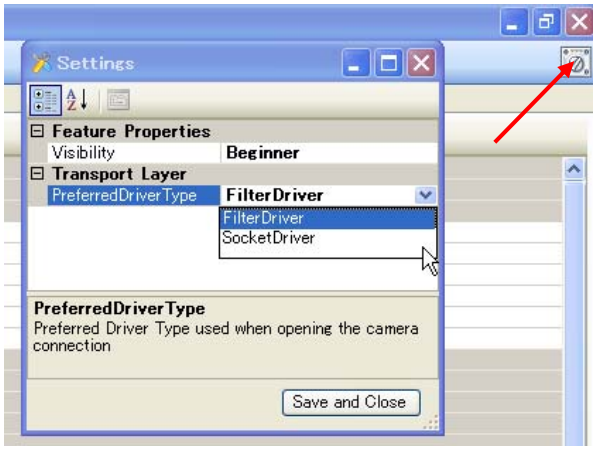
- The filter driver is installed as an optional function when JAI SDK is installed. If the filter driver is not installed at that time, it can be installed , All Programs ⇒ JAI SDK ⇒ GigE Vision Filter Driver ⇒ Install GigE Vision Filter Driver.



- If the Filter Driver is installed properly, the Camera Control Tool indicates “Driver Type Filter Driver” in the Network Interface.



- If it is not shown, confirm the setting as click “Settings Tab”.



8.2.9 Others

- If “Receive Descriptor” is set at its maximum value, same picture disturbance may occur due to “Hyper Threading” mode. If it happens, check that “Hyper Threading” is set at OFF. This is set in BIOS.

- When the image is being captured, if the frame rate is decreased, change the packet size. Each packet contains the header data and when the packet size is small, the total data including header information will increase. Depending on the performance of the computer used, the frame rate may be decreased. Confirm the packet size is increased. It can be set using the Camera Control Tool provided in JAI SDK.

8.3 Basic functions

The AM-1600GE/AB-1600GE camera is a progressive scan camera with a 16-mega pixel monochrome or Bayer mosaic color CCD. The interface to host PC is via Gigabit Ethernet.
Both models output digital video as 8-, 10- or 12-bit. The color version, AB-1600GE, outputs raw Bayer video. The camera also features several pre-processing functions (see chapter 8.4).
The camera has a partial scan function selectable as user programmable. It also features vertical binning mode (AM-1600GE only) for a faster frame rate and higher sensitivity.
There are 4 trigger modes in addition to continuous operation. Edge Pre-Select (EPS), Pulse Width Control (PWC), Sequence (in EPS mode) and Delayed Readout (in EPS and PWC modes) are available trigger modes.

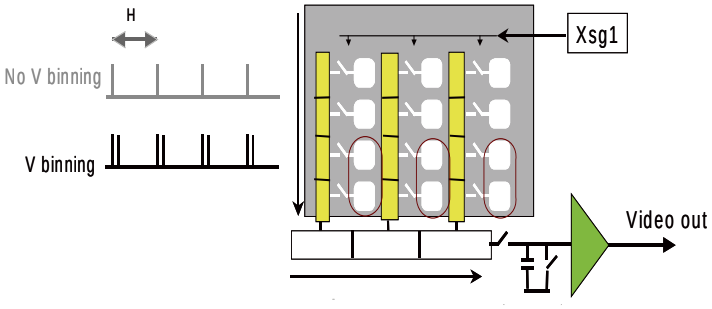
The functions are described in detail below.

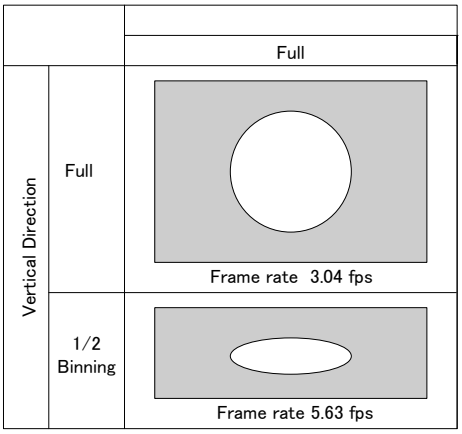
8.3.1 Vertical binning functions (AM-1600GE only)

This function is only available on the AM-1600GE camera.
The AM-1600GE incorporates the vertical binning mode described below.
The vertical binning mode is a function where the signal charges from 2 adjacent pixels in vertical direction are added together and read out as one pixel. Binning results in half the vertical resolution but a higher frame rate and higher sensitivity.

The frame rate of vertical binning is calculated as follows.
1 line in 2x binning mode = 3200 (clk) x 33.333333ns = 106.66µs
Total lines = 1665 lines

Frame rate = 1/(3200*1665*33.333333/1000000000)=5.63 fps





Setting	Value for Register address 0xA084	Resolution (in Output Video)	Frame rate
Off (no binning)	0x01	4872(h) x 3248(v) pixels	3.04 frames/sec.
2:1 binning	0x02	4872(h) x 1624(v) pixels	5.63 frames /sec.

Fig.15 Binning modes

8.3.2 Starting pixel – Bayer color mosaic

The AB-1600GE is a color camera based on a CCD sensor with a Bayer RGB color mosaic.
The color image reconstruction is done in the host PC. The color sequence in the video signal is dependent on the scan modes.

The AB-1600GE starts with a GR sequence in full scan mode. In partial scan mode, the starting line is user programmable (see next section). When an odd line is selected for the start, it starts with the GRG sequence. When an even line is selected, it starts with BGB sequence.

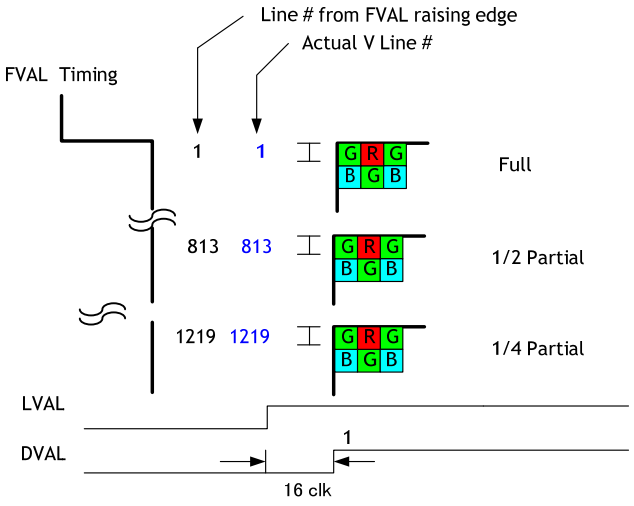


Fig.16 Bayer layout

8.3.3 Partial Scanning

The partial scanning function employed in AM/AB-1600GE is programmable.
The height of the image can be set from 800 lines as the minimum height and expanded to 3248 lines which is the full scan image. The starting point of the scan can be set from the first line to 2449th line, when the height is set to 800 lines.
The following describes the programmable partial scan image.

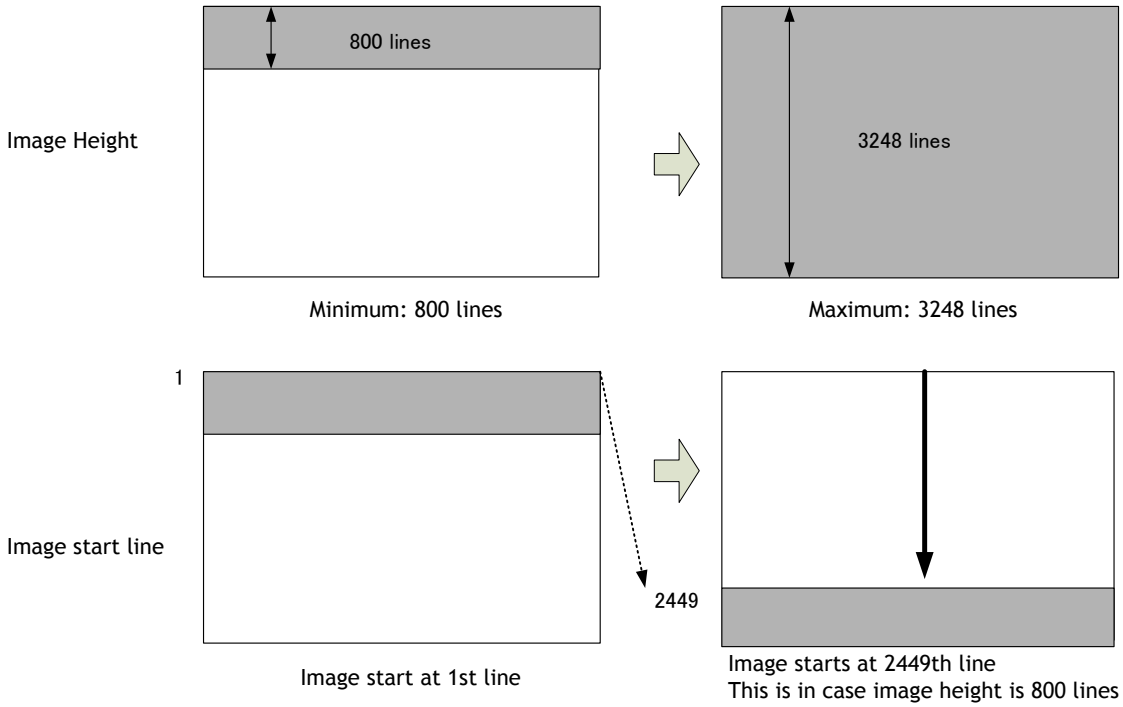


Fig.17 Variable partial scanning

8.3.4 Electronic Shutter

The AM-1600GE/AB-1600GE allows the shutter speed to be selected in three ways ; Programmable Shutter (up to 3327 line periods, 1 LVAL increments), Auto Shutter and Exposure Time Abs which is the GenICam standard.

◆ **Programmable Shutter**

The exposure time can be programmed in 98.6 μs (LVAL period) increments. The range is from 3 LVAL to 3327 LVAL. OFF is 3327 LVAL. (See the register map included in the SDK documentation for details how to configure this register - 0xA008)

	Minimum Shutter Time 3L	Maximum Shutter Time
Normal	98.6μs(1L) * 3L = 295.8 μs	98.6 μs * 3327L≈ 328 ms
V Binning	106.6 μs * 3 L = 319.8 μs	106.6 μs * 1665 L ≈ 177.5 ms

where, L is LVAL.

◆ **Exposure Auto Continuous (Auto Shutter)**

In this mode, the shutter continuously functions in order to get proper video output level in accordance with incoming light. The range of control is OFF(1/3 second) to 1/101.35 second.

◆ **Exposure Time Abs** (GenICam Standard)

This is a function specified in the GenICam standard.
The shutter speed can be entered as an absolute exposure time in microseconds (μs) in register address 0xA018. The entered absolute time (Time Abs) is then converted to programmable exposure (PE) value inside the camera.

The formula below shows the relationship between the PE value used by the camera for the different readout modes and the value entered in register 0xA018.
Due to rounding down, some errors may occur.

The relation between PE value and Time Abs
Normal readout PE= 3 + INT (Exposure time -296) μs / (2960/30000000)
V Binning readout PE= 3 + INT (Exposure time -320) μs / (3200/30000000)
Note: INT means round down

The following table shows minimum value and maximum value for each readout mode.

	Minimum value	Maximum Value
Normal Scan	296 μs	328264 μs
1/2 Partial Scan	296 μs	181448 μs
1/4 Partial Scan	296 μs	108040 μs
V-Binning Scan	320 μs	177600 μs

◆ **GPIO in combination with Pulse Width Control trigger**

More precise exposure time can be obtained by using GPIO in combination with Pulse Width mode. The clock generator and counter can be programmed in very fine increments.
For an example, refer to chapter 6.5.1.

8.3.1 Rear panel indicator

The rear panel mounted LED provides the following information:

Power Trig LED

- Amber: Power connected – initiating OS(approx. 20sec.)
- Red: Initiating the application (approx. 10sec.)
- Steady green: Camera is operating in continuous mode
- Flashing green: Camera is receiving an external trigger

LINK LED

- Steady green: 1000 Base-T has been connected
- No light: Not connected

ACT LED

- Steady Amber: Network active in communication
- No light: Network in stand-by

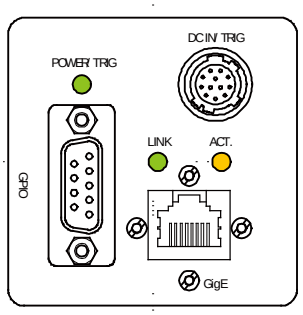


Fig.18 Rear Panel

Note: When the trigger is input in continuous mode, LED is not flashing. The flashing period does not coincide with the trigger interval.

8.3.2 Test signal generator

The AM-1600GE and the AB-1600GE have the Moving Ramp Scale test pattern generators. While the test pattern is selected, the video output is disabled. This function does not depend on the gain and offset. This function can be set by register but the setting is not stored in the memory.

8.4 Pre-processing functions (overview)

The AM-1600GE and the AB-1600GE have several pre-processing functions. The output from the camera is selectable from 8, 10 or 12-bit but the internal processing uses 16 bits quantization to digitize signals. Accordingly, the processing in the 16-bit domain results in a more precise image. The pre-processing functions include blemish compensation, shading compensation (including pixel non-uniformity), LUT(Look Up Table) and auto channel balance . A brief description of each function is included on the following pages.

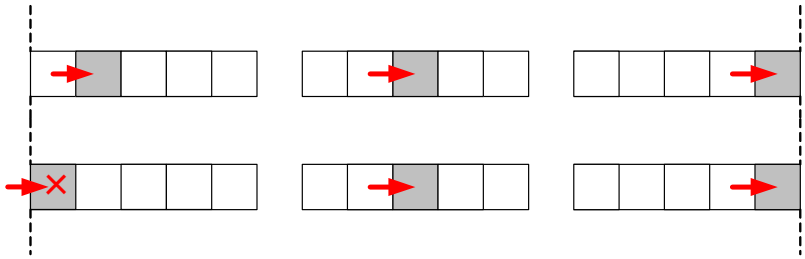
8.4.1 Blemish compensation (Register 0xA128) (AM-1600GE only)

The AM-1600CL has a blemish compensation circuit which may be set ON or OFF and a blemish detection function. This function compensates for blemishes on the CCD sensor (typically pixels with extremely high response or extremely low response). The detection process starts with black blemishes and then identifies white blemishes. The order of detection cannot be reversed. This applies to monochrome model only. Pixels that fulfill the blemish criteria can be compensated by using the adjacent pixel on the left side column as shown in the following figure.

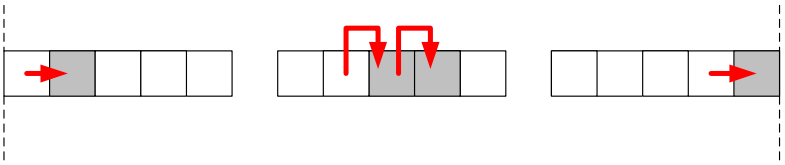
There is no limit to the number of pixels that can be compensated. As L channel and R channel images are composed as one image inside the camera, there is also no limitation on L channel and R channel compensation. When the circuit is set at ON, the default data (factory setting) can be used. This is OFF when shipped from the factory.

Functions Blemish compensation * ON or OFF
Detection process for black and while blemishes (see note)
Store the blemish data
Load the blemish data
Verify the data in RAM with Flash memory
Note: After completing the detection, the camera will run normally.

When the leftmost pixel has a blemish, it cannot be compensated because there is no data for compensation.



When two or more consecutive pixels have blemishes, the leftmost pixel with a blemish is compensated by the left normal pixel data and the second pixel is then compensated by the left pixel which is already compensated.



The default setting is Disable(OFF).

Fig.19 Blemish compensation (concept drawing)

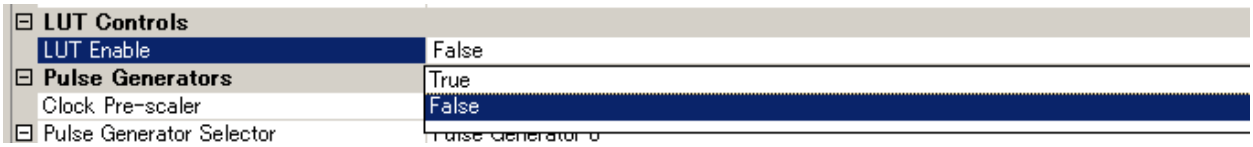
8.4.2 Shading Compensation (Pixel uniformity) (Register xA11C)(AM-1600GE only)

The shading compensation function can compensate different gain and offset on each pixel as well as the shading caused by lighting or optics. It is possible to use offset only (black-level correction) or offset and gain corrections in sequence.

Functions
- Black pixel level compensation
- Black pixel level and bright pixel gain compensation
- Black level calibration
- Bright gain calibration
- Store the result of compensation
- Load the stored data
- Verify the data in RAM with Flash memory

8.4.3 Programmable Look Up Table (LUT)

The AM-1600GE and AB-1600GE have a programmable look-up table (LUT) that has a 256 setting points (for Knee and gamma) which can be applied tothe full range of input signal. When LUT Enable is set at True, gamma 0.45 is applied.



8.4.4 Auto L/R channel balance (Registers 0xA0B8, 0xA0BC)

The AM-1600GE and AB-1600GE have a dual-tap readout architecture, with a Left (L) and Right (R) channel. In order to achieve the same gain and black level for both channels, the AM-1600GE and AB-1600GE have independent control for L channel and R channel gain and offset. In order to balance both channels, the balancing uses L channel as the reference and R channel is adjusted so as to have the same level as that of L channel for both gain and offset. For channel balancing, one-push operation or manual control can be applied.

Note: R/L channel balance must be set in Normal mode.

8.5. Other functions

8.5.1 Bayer White Balance (Register 0xA0D0) (AB-1600GE only)

Normally, the raw Bayer color signals are sent to the host PC as they are. In the host PC, the signals are interpolated to generate an RGB image and perform white balance.
In order to offload the host , the AB-1600GE can adjust Gr, R, Gb and B levels individually to get the white balance for the Bayer output signal. The gain is fixed to 1.0 for AM-1600GE.
The Bayer White Balance function includes manual white balance and one-push auto white balance.

Note: Bayer white balance must be set in Normal mode.

8.5.2 Automatic Gain Control(Registers, 0xA0B0 AGC select/0xA0B4 AGC reference)

This function maintains a constant output level in accordance with ambient brightness changes. This function is controlled by the set AGC command, which may be set to ON or OFF. The range for Automatic gain control is from -3dB to +12dB.

Note: This is available only in Normal mode.

8.6. Sensor layout and timing

8.6.1 CCD Sensor Layout

The CCD sensor layout with respect to pixels and lines used in the timing and video full frame read out is shown below.

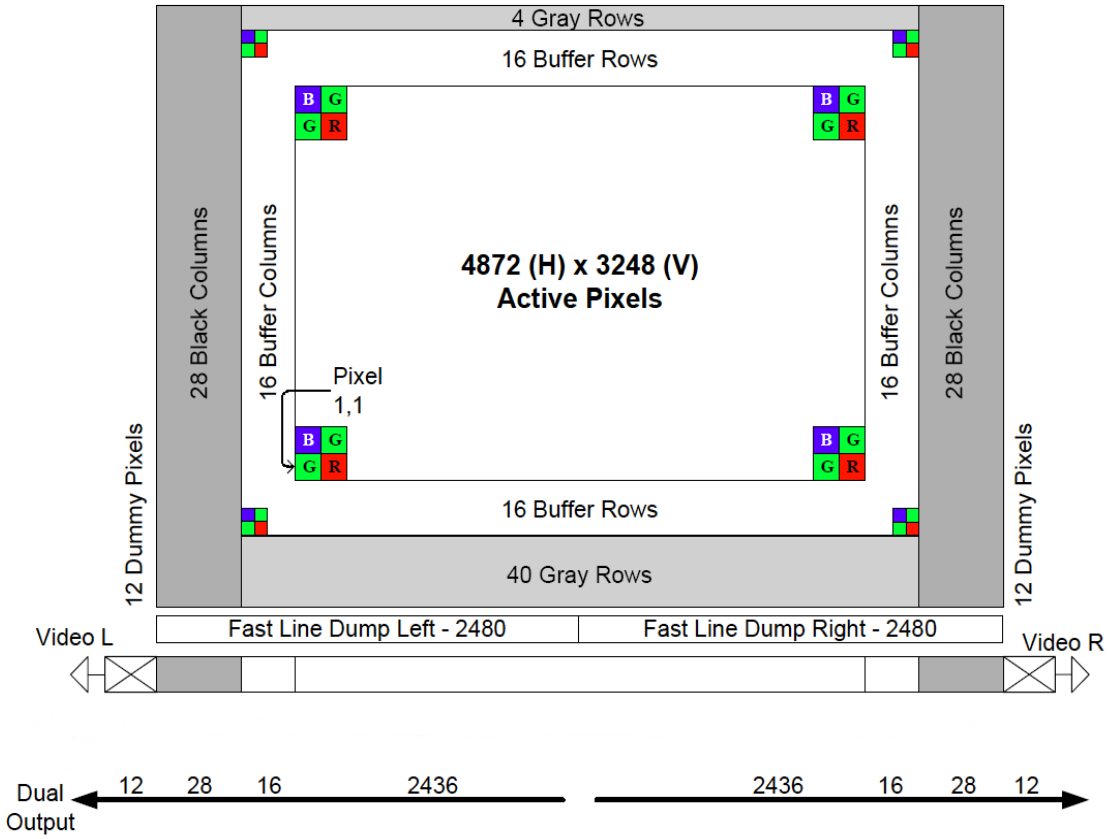


Fig.20 CCD sensor layout

Important Note: In the GigE Vision Standard, only the video part is normally transferred. In AM-1600GE and AB-1600GE, OB transfer mode can be selected. By using this mode, the user can add to the transfer a total of 48 additional pixels, including 8 pixels of OB and 16 pixels of buffer on the right end and 8 pixels of OB and 16 pixels of buffer on the left end.

8.6.2 Horizontal timing (Normal continuous mode)

The LVAL period is shown for normal continuous mode.
FULL FRAME READ OUT / PARTIAL READ OUT

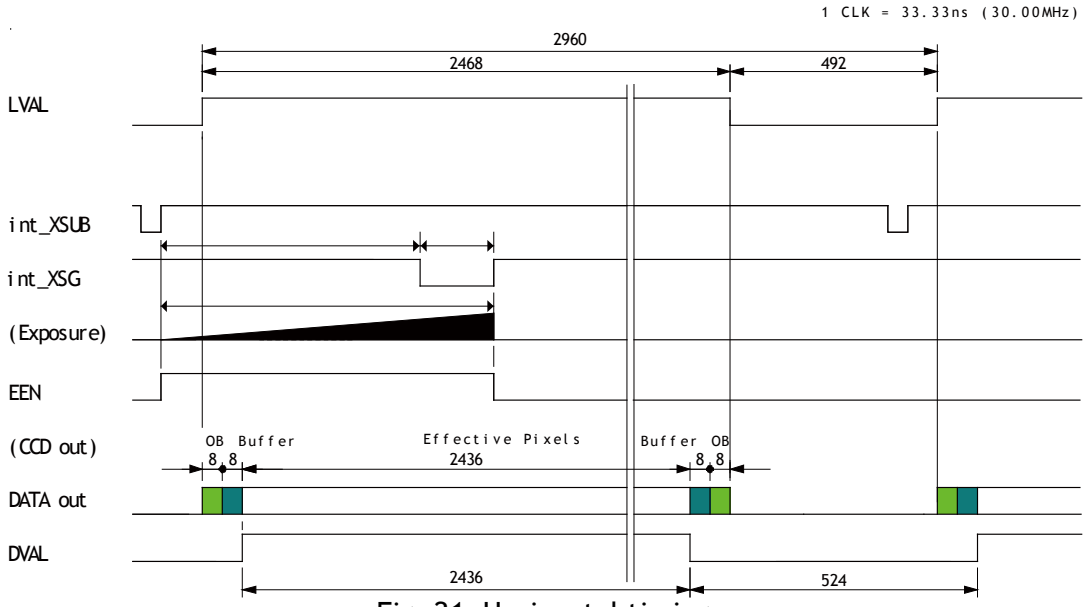


Fig. 21 Horizontal timing

8.6.3 Vertical timing (Normal continuous mode)

The FVAL period for normal continuous mode full scan is shown.

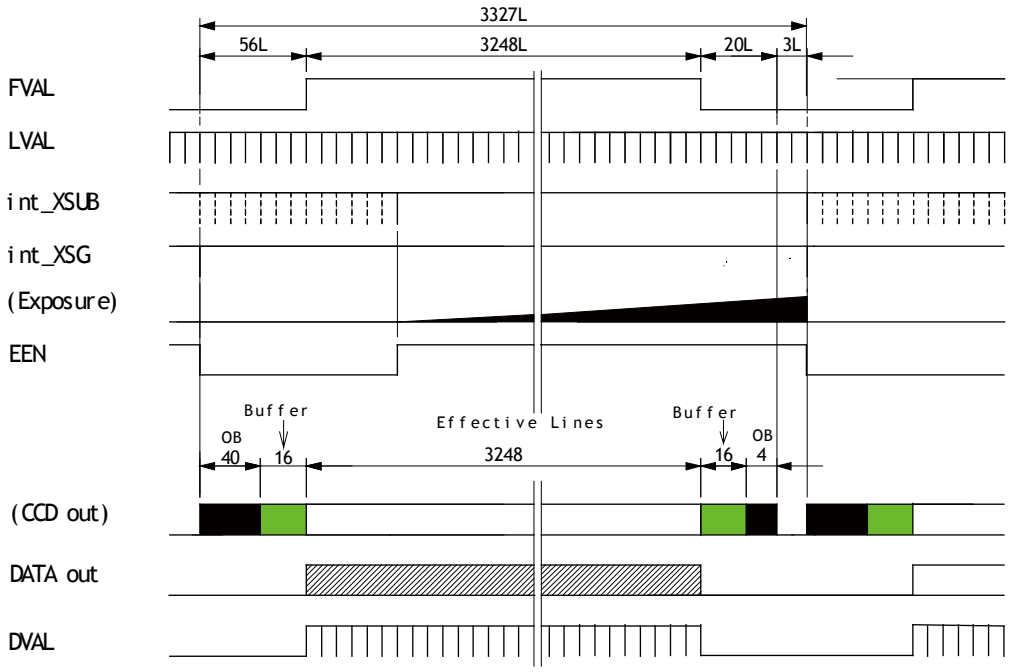


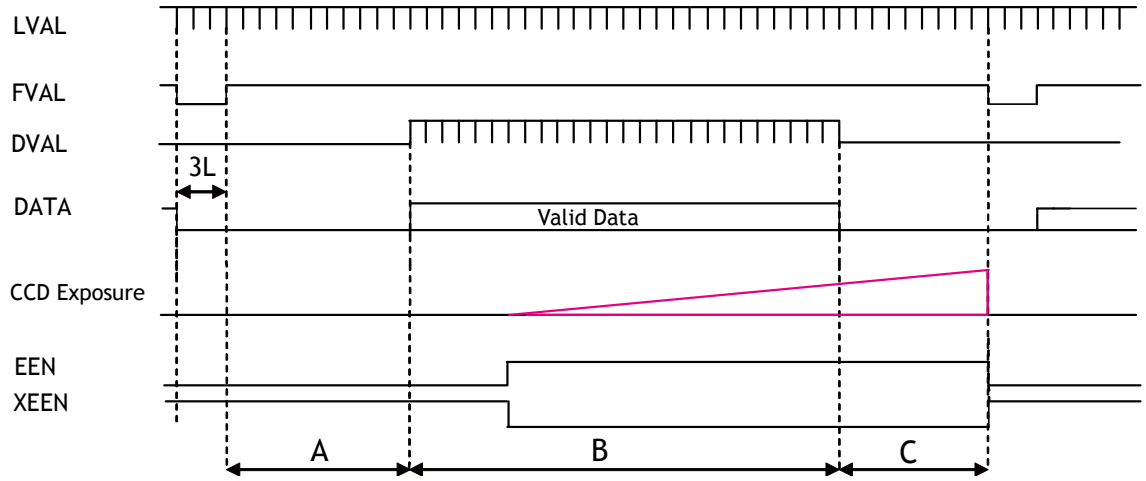
Fig. 22 Vertical timing for full scan

8.6.4 Partial Scanning

The timing for the partial scan mode in normal continuous mode is shown below.

■ **Vertical Timing**

The diagram below provides the vertical timing information.



Frame rate calculation formula

The frame rate can be calculated using the following formula.
In this formula, "Ceil" is round up. And(Top_Dump_line + Partial lines + Bottom_Dump_line)=3248

Total lines = 59 + A_line + Partial lines + B_line + 20

Frame Rate (fps) = 1 / (2960 * Total lines * 33.333333 / 1000000000)

Where,

A _line Ceil{(Top_Dump_line + 3)/12}, If Top_Dump_Line is 0, A_line is 0.

B_line Ceil{(Bottom_Dump_line + 3)/12}, If Bottom_Dump_line is 0, B_line is 0.

Example:

Case	Partial lines	Start line	H period (clock)	V period (Lines)	Frame rate (fps)	Calculation
1	1/2 (1624)	0	2960	1839	5.51	59+0+1624+136+20
2	1/2 (1624)	812	2960	1839	5.51	59+68+1624+68+20
3	1/2 (1624)	1624	2960	1839	5.51	59+136+1624+0+20
4	1/4(812)	0	2960	1095	9.25	59+0+812+204+20
5	1/4(812)	812	2960	1095	9.25	59+68+812+136+20
6	1/4(812)	2436	2960	1095	9.25	59+204+812+0+20

Fig. 23 Vertical timing for partial scanning

■ **Horizontal Timing**

The horizontal timing is the same as the Normal continuous mode.

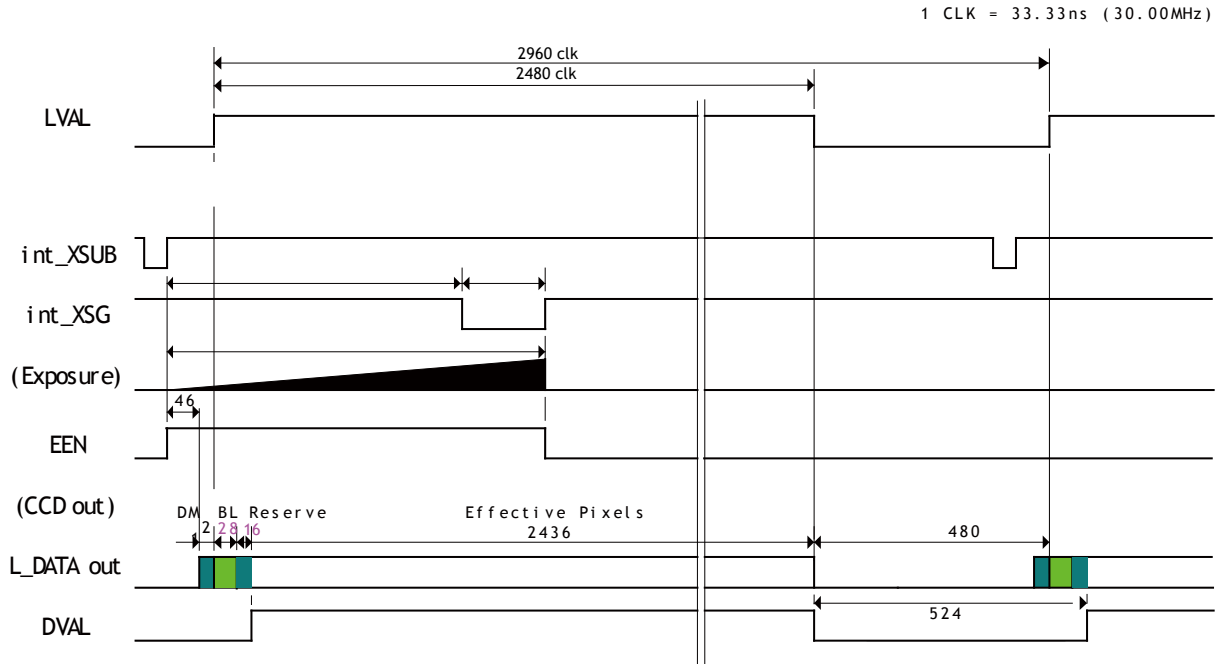


Fig.24 Horizontal Timing for Partial Scanning

8.6.5 Vertical binning (AM-1600GE only)

This function is available only for AM-1600GE.
The AM-1600GE has vertical binning mode. The vertical binning function combines charges from two adjacent rows, reducing the resolution to half and at the same time increasing frame rate and sensitivity. By activating this function, the frame rate is increased to 5.63 fps.

Important Note
Vertical binning cannot be used together with Partial scanning.

Frame rate calculation formula

The frame rate can be calculated as follows:
1 line in 2x binning mode = 106.66µs
Total lines = 1665 lines
Frame rate = 1/(3200*1665*33.333333/1000000000)=5.63 fps

■ Horizontal Timing (X2 vertical binning, Continuous mode)

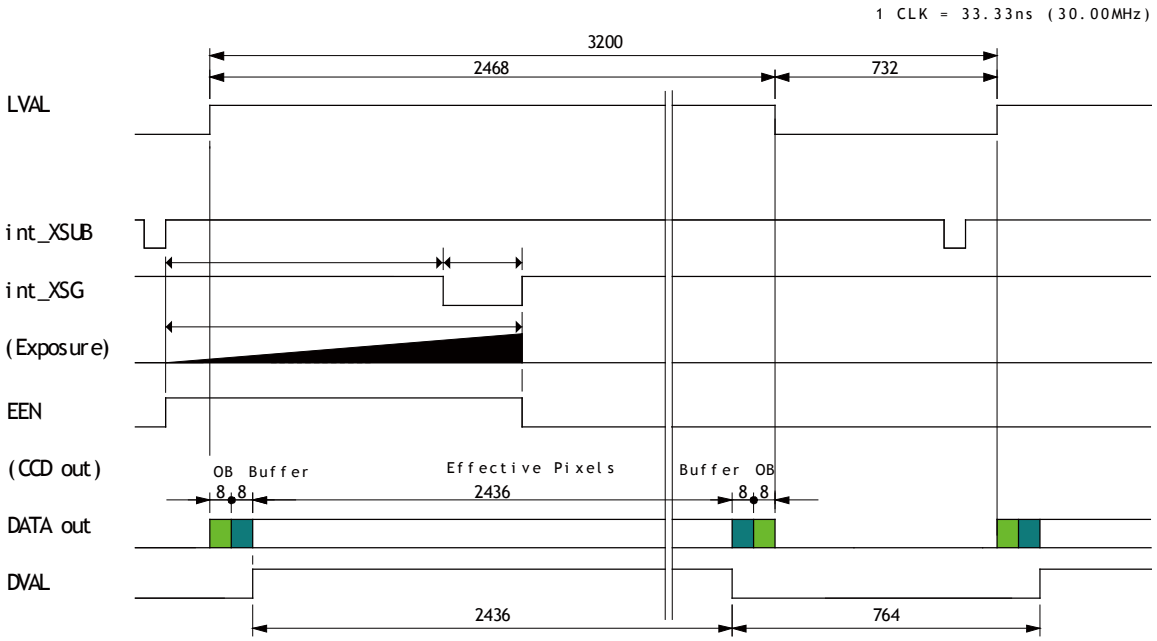


Fig.25 Horizontal Timing for Vertical Binning

■ Vertical timing (X2 vertical binning, Continuous mode)

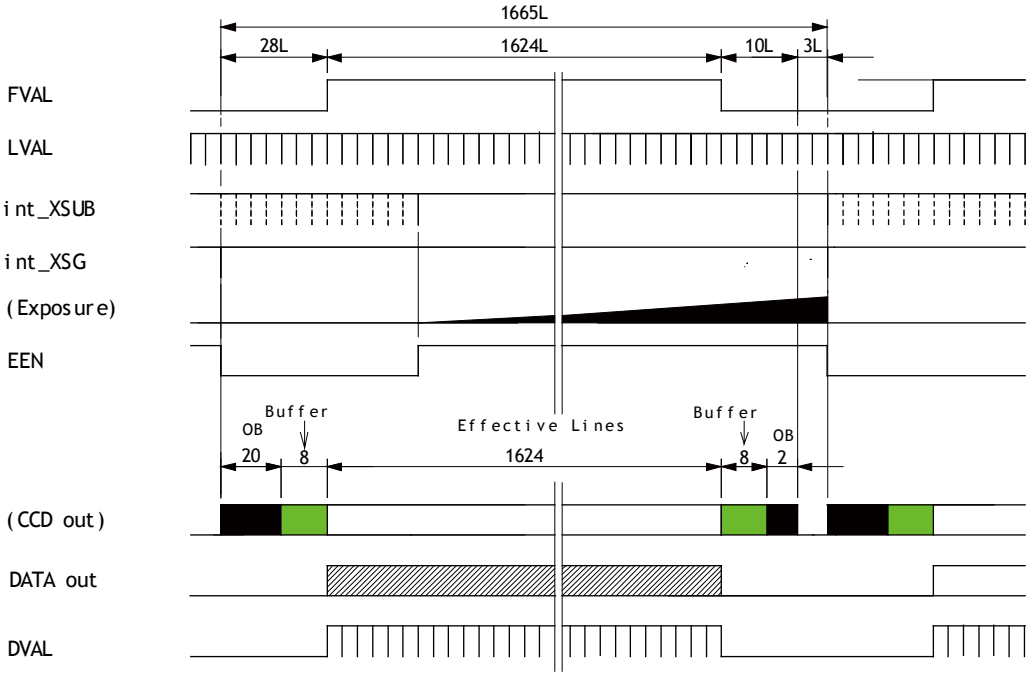


Fig.26 Vertical Timing for Vertical Binning

8.5 Operation Modes

This camera can operate in 5 primary modes.

1. Continuous Mode	Pre-selected exposure.
2. Edge Pre-select Mode (EPS)	Pre-selected exposure.
3. Pulse Width Control Mode (PWC)	Pulse width controlled exposure.
4. Sequence Trigger (EPS)	Pre-selected exposure (EPS)
5. EPS Delayed Readout Trigger	Pre-selected exposure (EPS)
6. PWC Delayed Readout Trigger	Pulse width controlled exposure)

8.5.1 Continuous operation

For applications not requiring asynchronous external triggering, this mode should be used.

For timing details, refer to fig. 21.through fig. 26.

To use this mode:

Set function:	Trigger mode	Continuous
	Scanning	Full, Partial scanning
	Vertical binning	On/Off (AM-1600GE only)
	Shutter mode	Programmable, Exposure Time Abs, Auto shutter
	Programmable exposure	3 to 3327 L

8.5.2 Edge Pre-select Trigger Mode (EPS)

An external trigger pulse initiates the capture, and the exposure time (accumulation time) is the fixed shutter speed set by registers. The accumulation can be LVAL a-synchronous only. The resulting video signal will start to be read out after the selected shutter time.

For timing details, refer to fig. 21.through fig. 26, Fig.27.

To use this mode:

Set function:	Trigger mode	EPS
	Scanning	Full, Partial
	Vertical binning	ON / OFF (AM-1600GE only)
	Shutter mode	Programmable, Exposure Time Abs, Auto
	Programmable exposure	3L to 3327 L
	Other functions and settings	
Input:	External trigger	GigE interface or 12-pin Hirose

Important notes on using this mode

- Trigger pulse >1 LVAL to <1 FVAL
- The minimum trigger interval is (3327L + Exposure time).

LVAL_async timing

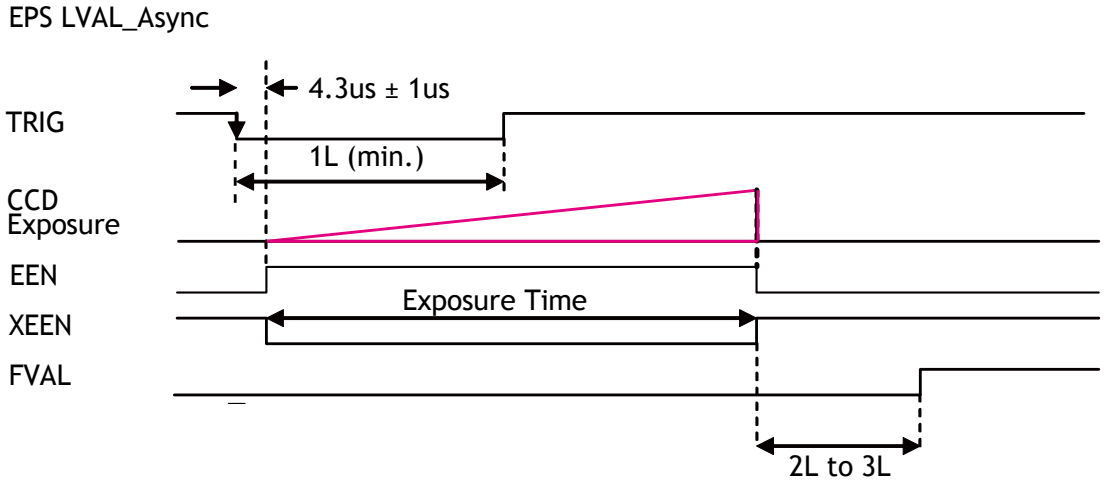


Fig.27 Edge Pre-select LVAL async Timing

8.5.3 Pulse Width Control Trigger Mode (PWC)

In this mode the accumulation time is equal to the trigger pulse width. Here it is possible to have a long time exposure. The maximum recommended time is <2 seconds however, depending on your application, slightly longer exposure may still produce an acceptable signal-to-noise ratio.
The accumulation can be LVAL asynchronous only.
The resulting video signal will start to be read out after the trigger rising edge.

For timing details, refer to fig. 21.through fig.26, fig.28.

To use this mode:

Set function:	Trigger mode	PWC
	Scanning	Full, Partial
	Vertical binning	ON / OFF(AM-1600GE only)
	Other functions and settings	
Input:	External trigger	GigE interface or 12-pin Hirose

Important notes on using this mode

- Trigger pulse width >1LVAL to <2 seconds
- The minimum trigger interval is (3331L + Exposure time).

LVAL_async timing

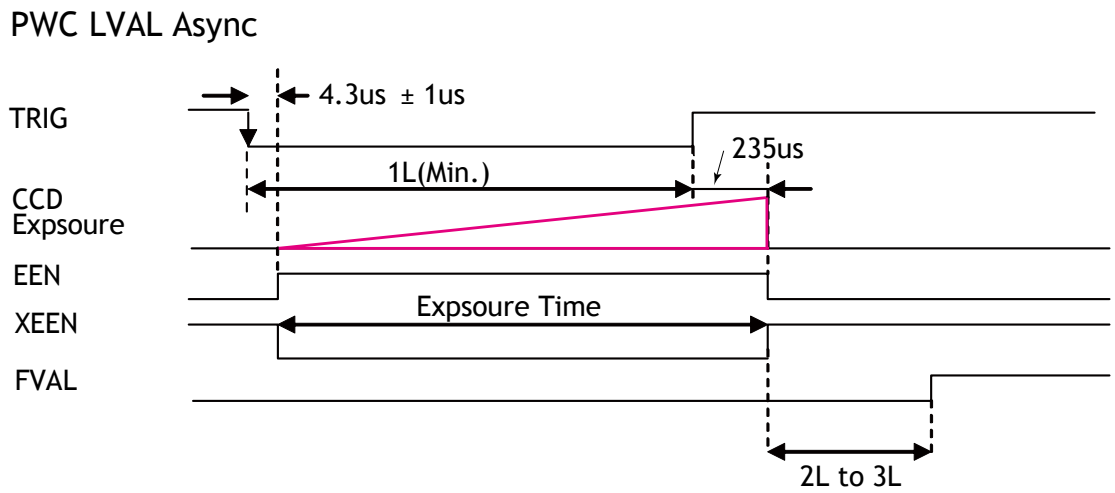
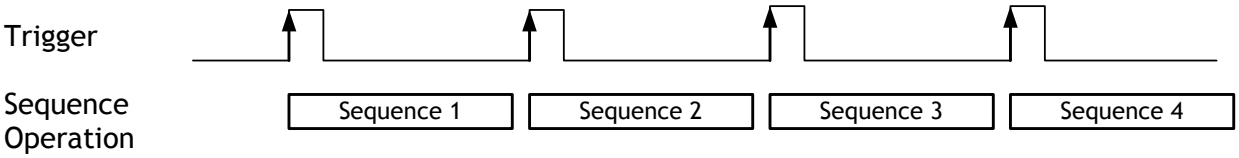


Fig.28 Pulse Width control LVAL a-sync

8.5.4 Sequence Trigger Mode (EPS)

This mode allows the user to define a preset sequence up to 10 images, each with its own ROI, Shutter and Gain values. As each trigger input is received, the image data with the preset sequence is output as described below.



Signals added to a trigger can be selected by 0xB060 Camera Trigger Selector in the register map via GPIO. The camera will function on the rising edge of the trigger and Negative or Positive should be determined accordingly.

The following default settings can be modified by the user to define a sequence.

ID	ROI				Shutter	Gain	Repeat number for each ID 1-50
	Width	Height	Offset X	Offset Y			
1	4872	3248	0	0	3327	0	1
2	4872	3248	0	0	3327	0	1
3	4872	3248	0	0	3327	0	1
4	4872	3248	0	0	3327	0	1
5	4872	3248	0	0	3327	0	1
6	4872	3248	0	0	3327	0	1
7	4872	3248	0	0	3327	0	1
8	4872	3248	0	0	3327	0	1
9	4872	3248	0	0	3327	0	1
10	4872	3248	0	0	3327	0	1

The following registers are used to configure the sequence.

0xC0F4 Sequence Repetitions (Number of Repetitions)
0xC0F8 Sequence Ending Position (Ending Position)
0xA30C Sequence Reset Command (1 only)
0xB060 Selection for camera trigger 0
0xA040 Trigger mode selection and 0x09 for Sequential EPS mode

Example of settings

Setting: Repeat 5 times from ID 1 through ID 8

0xC0F4 Set to 0x05
0xC0F8 Set to 0x08
0xB060 For instance, 12p #6 for Optical IN 1
0xA040 Sequential PS (9)
0xA3F0 Set this for start
0xA040 Set Normal Mode (0) for stop

Please refer to the detailed register description on Camera Register Map which is included in the SDK.

The following table shows the minimum trigger interval in synchronous accumulation mode. As EPS sequential trigger mode works only in LVAL asynchronous mode, the exposure time is added to the table below. It is necessary to input the trigger signal so that the timing should be LVAL asynchronous.

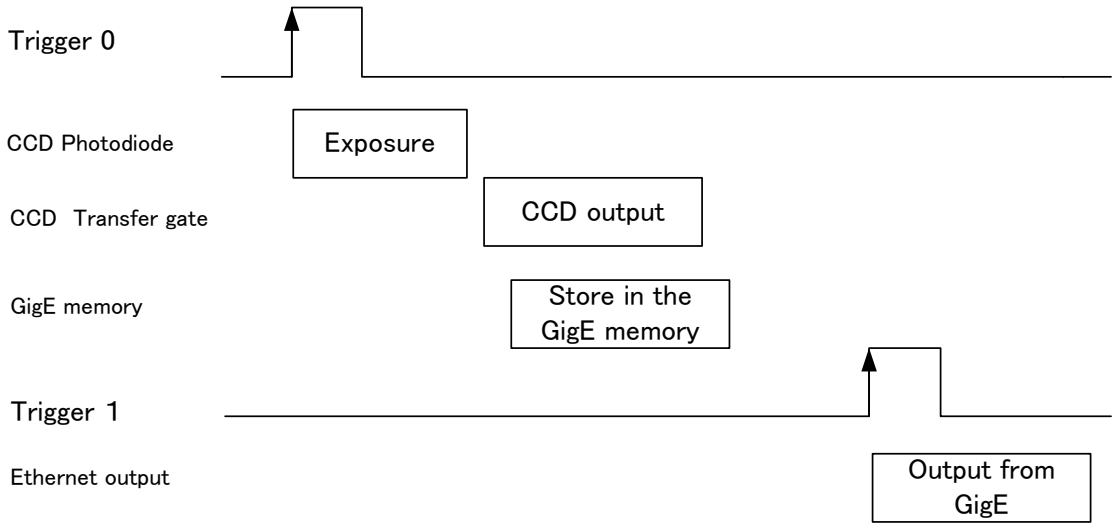
Full Scan	1/2 Partial	1/4 Partial	1/2 V Binning
340 ms	185 ms	110 ms	180 ms

- The conditions for this table are that shutter speed should be set the same for all IDs in the sequence. If the shutter speed is different, the difference of exposure time should be added.
- It is recommended to set the exposure time in the order from the shortest to the longer one.
- The above table shows the interval at PE=3(minimum). When the exposure is longer than PE=3,the interval is (Value in the table - 3) + Exposure lines (PE value).
- Do not input the trigger just after the sequence is reset. It requires at least 500ms delay.
- ROI can be set by 24 pixels unit in horizontal way. In vertical way, 1 line for AM-1600GE and 2lines for AB-1600GE can be set for ROI.

8.5.5 Delayed Readout Mode (EPS, PWC)

This mode can be used to delay the transmission of a captured image. When several cameras are triggered simultaneously and connected to the same GigE interface, it allows the cameras to be read out in sequence, preventing congestion.

The image data is not transmitted directly by the trigger 0 and it is stored in the memory located at Ethernet Interface. By the falling edge of the soft trigger 1, the image data is output.



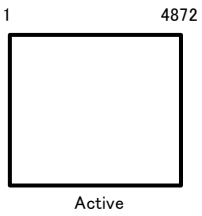
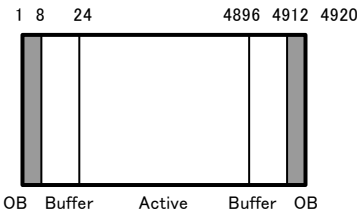
Example of setting

0xA040 EPS Delayed Readout (0x17)
0xB060 Trigger 0 select, e.g. 0x04 OPT IN 1
0xB-064 Trigger 1 select, e.g. 0x05 OPT IN 2

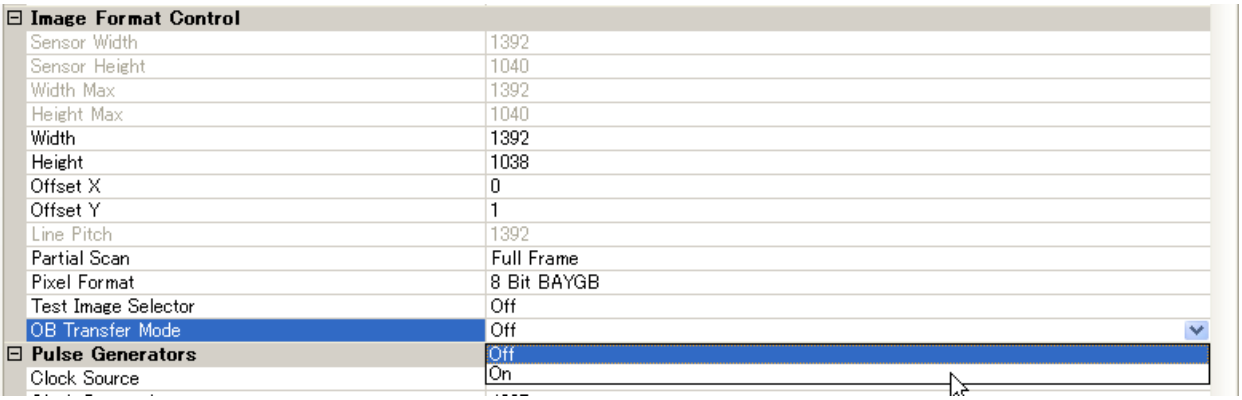
For the details of Registers, please refer to the Camera Register Map included in the SDK.

8.5.6 Optical Black transfer Mode

It is possible for the user to decide whether the optical black (OB) portion of the image will be transferred or not. The optical black part can be used for black reference in the application software. Setting register 0xA41C turns the optical black transfer ON or OFF. The default condition is OFF.

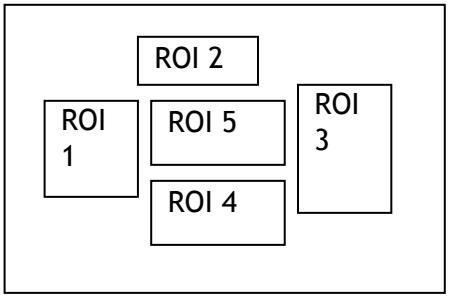
Normal	OB Transfer mode
	 Increase 8 pixels of OB and 16 pixels of buffer on both side.

Note: The menu for ON or OFF of OB transfer mode is found on the Image Format Control of JAI SDK Camera Control Tool.



8.5.7 Multi ROI mode (Multi Region of Interest)

In this mode, at maximum of 5 ROIs located on one image can be output by one trigger input. By using this mode, the data stream can be smaller.
Each ROI can be overlapped. However, if the total size of the accumulated 5 ROIs is larger than that of 1 frame, the frame rate might be decreased.
It is recommended to determine the size of each ROI after calculating the total size.



8.6 Operation Mode and Functions matrix

ID (Value) Note 1	Mode	Shutter Program./ Auto Exposure (note2)	Vertical Binning (Note 3)	Partial Scanning	Multi ROI	LVAL Sync/ Async
0x00	Continuous	Yes	Yes	Yes	No	---
0x01	Edge Pre-select (EPS)	Yes	Yes	Yes	Yes	Async
0x02	Pulse Width Control (PWC)	Not applicable	Yes	Yes	Yes	Async
0x09	Sequential Pre-select (EPS)	Yes	Yes	Yes	No	Async
0x11	EPS Delayed Readout	Yes	Yes	Yes	Yes	Async
0x12	PWC Delayed Readout	Yes	Yes	Yes	Yes	Async

Note 1: Write ID in register address 0xA040 in order to set trigger mode.
Note 2: Auto exposure is available only in continuous mode.
Note 3: Vertical Binning is available only for AM-1600GE.

9. Register Map

The following table provides detailed information for the hardware registers used for controlling the camera and obtaining information on the status of the camera. The content of this register map is also found in the XML file, as stipulated by the GenICam standard.

Generic Registers:

Address	Function	Read/ Write	Size	Value / Range of value	Description	Default value
0x0000	Version	R	4	Major vector	Version of the GigE Standard to which the device is compliant.	0001
				Minor vector		0000
0x0004	Is Big Endian	R	4	Bit0:Endianness	0:Little endian 1:Big endian	1
				Bit24~31: Character set index	1:UTF-8	1
0x0008	Device MAC address (high)	R	4		Upper 4 bytes of the MAC address	
0x0010	IP	R	4	Bit 31: persistent Bit 30: DHCP Bit 29: LLA	Bits can be OR-ed. All other bits are reserved and set to 0. DHCP and LLA bits must be on.	1
						1
						1
0x0014	Current IP Configuration	R W	4	Bit 31: persistent Bit 30: DHCP Bit 29: LLA	Bits can be OR-ed. LLA is always activated and is read only.	0
						1
						1
0x0024	Current IP address	R	4			
0x0034	Current subnet mask	R	4			
0x0044	Current default gateway	R	4			
0x0048	Manufacturer's name	R	32		e.g. JAI	
0x0068	Device Model name	R	32		e.g. AM-1600GE	
0x0088	Device version	R	32			
0x00A8	Device Manufacturer info	R	48		Provides extended manufacturer information about the device.	
0x00D8	Device ID	R	16		Camera serial number	
0x00E8	Device User ID	R W	16		User assignable string	
0x0200	First choice of URL for XML	R	512		File extension .XML indicates uncompressed text file. File extension .ZIP indicates compressed using ZIP.	
0x0400	Second choice of URL for XML	R	512			
0x0600	Number of interfaces	R	4		Indicates the number of physical network interfaces on this device.	1
0x064C	Persistent IP address	R W	4		Valid if Persistent IP is enabled	0xC0A86401
0x065C	Persistent subnet mask	R W	4		Valid if Persistent IP is enabled	0xFFFFFF00

Address	Function	Read/ Write	Size	Value / Range of value	Description	Default value
0x066C	Persistent gateway	R W	4		Valid if Persistent IP is enabled	0x00000000
0x0900	Messaging channel count	R	4	This camera has 1	number of available message channel	1
0x0904	Stream channel count	R	4	This camera only has 1	number of available stream channel	1
0x0934	GVCP capability	R	4	Bit 0:User defined name Bit 1:serial No. Bit 2 ~26:reserved Bit 27:EVENTDATA Bit 28:EVENT Bit29:ACKETRESEND Bit 30:WRITEMEM Bit 31:multiple read	This is a capability register indicating which one of the non-mandatory GVCP commands are supported by this device.	
0x0938	Heartbeat timeout	R W	4	0b to 4294967295	In milliseconds. Internally, the heartbeat is rounded according to the clock used for heartbeat.	3000 or 15000
0x093C	Timestamp tick frequency (High)	R	4	Timestamp tick frequency is 0 if timestamp is not supported.	64-bit value indicating the number of timestamp clock ticks in 1 second. This register holds the most significant bytes.	0
0x0940	Timestamp tick frequency (Low)	R	4		This register holds the least significant bytes.	62500000
0x0944	Timestamp control Reset	W	4	Bit 0: Reset Bit 1:latch current timestamp	Used to latch the current timestamp value. No need to clear to 0.	
0x0948	Timestamp (High)	R	4		Latched value of the timestamp (most significant bytes)	
0x094C	Timestamp (Low)	R	4		Latched value of the timestamp (least significant bytes)	
0x0a00	CCP(Control Channel Privilege)	R W	4	0:Disconnect 1:Exclusive 2:Control 3:Exclusive Control	control channel privilege register	0
0x0b00	MCP(Message Channel Port)	R W	4		message channel port register	0
0x0b10	MCDA(Message Channel Destination Address)	R W	4	Not specified	message channel destination address register	
0x0b14	MCTT(Message Channel Transmission Timeout)	R W	4		message channel transfer timeout: ms	300
0x0b18	MCRC(Message Channel Retry count)	R W	4		message channel retry count	2
0x0d00	SCP(Stream Channel Port)	R W	4		primary stream port register	
0x0d04	SCPS(Stream Channel Packet Size)0	R W	4	1476 to 16020	primary stream channel packet size register/ packet size includes IP, UDP&GVSP Header	1476

Address	Function	Read/ Write	Size	Value / Range of value	Description	Default value
0x0d08	SCPD(Stream Channel Packet Delay)	R W	4	0 to 125000	primary stream channel packet delay register	0
0x0d18	SCDA(Stream Channel Destination Address)	R W	4		primary stream channel destination address register	
0xA6DC	FPGA version	R	4	YYMMDDVR		

Standard camera functions registers:

Address	Function	Read/ Write	Size	Value / Range of value	Description	Default value
0xA000	Shutter mode	R W	4	1= Prog. exposure 2= Exp.TimeAbs 3=Auto exposure	Sets exposure time for image capture.	0
0xA008	Exposure time in RAW format	R W	4	3 to 3327(OFF)	Flexible setting of exposure time ranging from 296 µs to 328 ms using the LVAL period (L) as increment. 1L is 32us.	3327
0xA018	Exposure TimeAbs (single)	R W	4	296 to 328264(OFF)	Actual exposure time in microseconds, µs. The camera will round value off to match LVAL increments.	328264
0xA030	Auto Exposure Value	R O			Auto shutter value	
0xA040	Exposure Mode	R W	4	0x00=Continuous 0x01=Edge pre-select 0x02=Pulse width control 0x09=Sequential EPS 0x17=Delayed EPS 0x18=Delayed PWC	Trigger mode	0
0xA080	Partial Scan (Vertical)	R W	4	0=Full Frame 2=1/2 Partial 3=1/4 Partial 15= Variable		0
0xA084	Binning vertical	R W	4	1=Binning OFF 2=1/2 V Binning	AM-1600GE only	1
0xA088	Variable Partial scan start line	R W	4	0 to 2447	On variable mode	2
0x08C	Variable Partial scan Num. of lines	R W	4	800 to 3248	On variable mode	2056
0xA09C	Channel level adjust	R W	4	0 to 65535	R ch Digital Fine gain	8192
0xA0A0	Pixel Gain Gr	R W	4	0 to 65535	Mono : Digital (All) Bayer : Digital Gr	8192
0xA0A4	Pixel Gain Gb	R W	4	0 to 65535	Digital Gb	8192
0xA0A8	Pixel Gain R	R W	4	0 to 65535	Digital R	8192

Address	Function	Read/ Write	Size	Value / Range of value	Description	Default value
0xA0AC	Pixel Gain B	R W	4	0 to 65535	Digital B	8192
0xA0B0	AGC	R W	4	0=OFF 1=ON		0
0xA0B4	AGC/Auto shutter reference	R W	4	0 to 8191		0
0xA0B8	Gain Auto Balance once	W	4	0= execute		0 only
0xA0BC	Black Level Auto Balance once	W	4	0= execute		0 only
0xA0C0	Balance White Auto	R W	4	0=Manual/One-push	AB-1600GE only	0
0xA0C4	Manual Gain Level	R W	4	0 to 1535	-3dB to +12dB	224
0xA0C8	Auto Gain Value	R O	4		Auto gain value on AGC=ON	
0xA0D0	One push Auto white balance	W	4	0= execute		0 only
0xA0D4	AWB area	R W	4	0=All pixels 1=Middle band pixels 3=Centre pixels		0
0xA0D8	Auto Balance Status	R	4	0=Complete 1=Too bright 2=Too dark 3=Time error 4=Busy 5=Limit 6=Trigger is not set at normal		
0xA0E0	User Black level	R W	4	0 to 255		128
0xA11C	Shading Correction	R W	4	0=Off 1=Flat_Offset 3=Flat_Offset_Gain 9=Calibration dark shading 10=Calibration bright shading Bit27=Save shading Bit26=Load shading Bit25=Verify shading		0
0xA128	Blemish reduction	R W	4	0=OFF 1=ON Bit30=Calibration Dark blemish Bit29=Calibration bright blemish Bit28=Save Bit276=Load Bit26=Verify		0

Address	Function	Read/ Write	Size	Value / Range of value	Description	Default value
0xA13C	Test Stream (Jumbo Packet Check)	R W	4	0=OFF 6=Moving Ramp scale		0
0xA148	Blemish calibration status and progress	R W	4	31-24 bit: 0=completed 1=Too bright 2=Too dark 3=Time out error 4=Busy 5=Limt 6=Trigger is not set as Normal mode 23-16 bit: Progress indication (0% to 100%) 15 – 0 bit: Error count of verify		0xA148
0xA14C	Shading calibration status and progress	R W	4	31-24 bit: 0=completed 1=Too bright 2=Too dark 3=Time out error 4=Busy 5=Limt 6=Trigger is not set as Normal mode 23-16 bit: Progress indication (0% to 100%) 15 – 0 bit: Error count of verify		
0xA1FC	Temperature	R	4	0.0625°C step, Specified range: -40 °C	-55 °C to 150 °C	
0xA200	LUT Enable	R W	4	0:OFF 1:ON		0
0xA300	User set save	W	4	1=User area1	Allows use to save all camera settings. Last used area number becomes new default.	1
0xA304	User set Load	W	4	0=Factory area 1=User area1	Allow the user to recall all camera settings.	0
0xA308	Current User Set Selector	R	4	0=Factory area 1=User area 1		0
0xA30C	Save Sequence settings	W	4	1 only		1

Sequence function registers:

0xC000	Sequence Shutter 1	R W	4	3 to 3327	Pre-program 1st shutter value	3327
0xC004	Sequence Shutter 2	R W	4	3 to 3327	Pre-program 2nd shutter value	3327

Address	Function	Read/ Write	Size	Value / Range of value	Description	Default value
0xC008	Sequence Shutter 3	R W	4	3 to 3327	Pre-program 3rd shutter value	3327
0xC00C	Sequence Shutter 4	R W	4	3 to 3327	Pre-program 4th shutter value	3327
0xC010	Sequence Shutter 5	R W	4	3 to 3327	Pre-program 5th shutter value	3327
0xC014	Sequence Shutter 6	R W	4	3 to 3327	Pre-program 6th shutter value	3327
0xC018	Sequence Shutter 7	R W	4	3 to 3327	Pre-program 7th shutter value	3327
0xC01C	Sequence Shutter 8	R W	4	3 to 3327	Pre-program 8th shutter value	3327
0xC020	Sequence Shutter 9	R W	4	3 to 3327	Pre-program 9th shutter value	3327
0xC024	Sequence Shutter 10	R W	4	3 to 3327	Pre-program 10th shutter value	3327
0xC078	Sequence Gain 1	R W	4	-224 to 1311	Pre-program 1st Gain value	0
0xC07C	Sequence Gain 2	R W	4	-224 to 1311	Pre-program 2nd Gain value	0
0xC080	Sequence Gain 3	R W	4	-224 to 1311	Pre-program 3rd Gain value	0
0xC084	Sequence Gain 4	R W	4	-224 to 1311	Pre-program 4th Gain value	0
0xC088	Sequence Gain 5	R W	4	-224 to 1311	Pre-program 5th Gain value	0
0xC08C	Sequence Gain 6	R W	4	-224 to 1311	Pre-program 6th Gain value	0
0xC090	Sequence Gain 7	R W	4	-224 to 1311	Pre-program 7th Gain value	0
0xC094	Sequence Gain 8	R W	4	-224 to 1311	Pre-program 8th Gain value	0
0xC098	Sequence Gain 9	R W	4	-224 to 1311	Pre-program 9th Gain value	0
0xC09C	Sequence Gain 10	R W	4	-224 to 1311	Pre-program 10th Gain value	0
0xC0F0	Reset Sequence settings	W	4	1 only	Sequence Reset	1
0xC0F4	Sequence repetition count	R W	4	0 to 255	Number of repetition	0
0xC0F8	last sequence	R W	4	1 to 10	Ending position	1
0xC0FC	Sequence ROI size- X1	R W	4	24 to 4872		Width max
0xC100	Sequence ROI Size- X2	R W	4	24 to 4872		Width max
0xC104	Sequence ROI Size- X3	R W	4	24 to 4872		Width max
0xC108	Sequence ROI Size- X 4	R W	4	24 to 4872		Width max
0xC10C	Sequence ROI size- X5	R W	4	24 to 4872		Width max
0xC110	Sequence ROI Size- X 6	R W	4	24 to 4872		Width max

Address	Function	Read/ Write	Size	Value / Range of value	Description	Default value
0xC114	Sequence ROI size- X7	R W	4	24 to 4872		Width max
0xC118	Sequence ROI Size- X8	R W	4	24 to 4872		Width max
0xC11C	Sequence ROI size- X9	R W	4	24 to 4872		Width max
0xC120	Sequence ROI Size- X10	R W	4	24 to 4872		Width max
0xC124	Sequence ROI Size-Y1	R W	4	8 to 3248		Height Max
0xC128	Sequence ROI Size-Y2	R W	4	8 to 3248		Height Max
0xC12C	Sequence ROI Size-Y3	R W	4	8 to 3248		Height Max
0xC130	Sequence ROI Size-Y4	R W	4	8 to 3248		Height Max
0xC134	Sequence ROI Size-Y5	R W	4	8 to 3248		Height Max
0xC138	Sequence ROI Size-Y6	R W	4	8 to 3248		Height Max
0xC13C	Sequence ROI Size-Y7	R W	4	8 to 3248		Height Max
0xC140	Sequence ROI Size-Y8	R W	4	8 to 3248		Height Max
0xC144	Sequence ROI Size-Y9	R W	4	8 to 3248		Height Max
0xC148	Sequence ROI Size-Y10	R W	4	8 to 3248		Height Max
0xC14C	Sequence ROI Offset-X1	R W	4	0 to 4864		0
0xC150	Sequence ROI Offset-X2	R W	4	0 to 4864		0
0xC154	Sequence ROI Offset-X3	R W	4	0 to 4864		0
0XC158	Sequence ROI Offset-X4	R W	4	0 to 4864		0
0xC15C	Sequence ROI Offset-X5	R / W	4	0 to 4864		0
0xC160	Sequence ROI Offset-X6	R W	4	0 to 4864		0
0xC164	Sequence ROI Offset-X7	R W	4	0 to 4864		0
0xC168	Sequence ROI Offset-X8	R W	4	0 to 4864		0
0xC16C	Sequence ROI Offset-X9	R W	4	0 to 4864		0
0xC170	Sequence ROI Offset-X10	R W	4	0 to 4864		0
0xC174	Sequence ROI Offset-Y1	R W	4	0 to 3240		0
0xC178	Sequence ROI Offset-Y2	R W	4	0 to 3240		0

Address	Function	Read/ Write	Size	Value / Range of value	Description	Default value
0xC17C	Sequence ROI Offset-Y3	R W	4	0 to 3240		0
0xC180	Sequence ROI Offset-Y4	R W	4	0 to 3240		0
0xC184	Sequence ROI Offset-Y5	R W	4	0 to 3240		0
0xC188	Sequence ROI Offset-Y6	R W	4	0 to 3240		0
0xC18C	Sequence ROI Offset-Y7	R W	4	0 to 3240		0
0xC190	Sequence ROI Offset-Y8	R W	4	0 to 3240		0
0xC194	Sequence ROI Offset-Y9	R W	4	0 to 3240		0
0xC198	Sequence ROI Offset-Y10	R W	4	0 to 3240		0
0xC19C	Sequence ROI Internal Repetition 1	R W	4	1 to 50		0
0xC1A0	Sequence ROI Internal Repetition 2	R W	4	0 to 255		0
0xC1A4	Sequence ROI Internal Repetition 3	R W	4	0 to 255		0
0xC1A8	Sequence ROI Internal Repetition 4	R W	4	0 to 255		0
0xC1AC	Sequence ROI Internal Repetition 5	R W	4	0 to 255		0
0xC1B0	Sequence ROI Internal Repetition 6	R W	4	0 to 255		0
0xC1B4	Sequence ROI Internal Repetition 7	R W	4	0 to 255		0
0xC1B8	Sequence ROI Internal Repetition 8	R W	4	0 to 255		0
0xC1BC	Sequence ROI Internal Repetition 9	R W	4	0 to 255		0
0xC1C0	Sequence ROI Internal Repetition 10	R W	4	0 to 255		0

GigE Vision streaming related registers:

Address	Function	Read/ Write	Size	Value / Range of value	Description	Default value
0xA400	Horizontal Image Size	R	4			4872
0xA404	Vertical Image Size	R	4		return proper value when normal, V-bin & partial	3248

Address	Function	Read/ Write	Size	Value / Range of value	Description	Default value
0xA410	Video Pixel Format Type	R W	4	**AM-1600GE** 0x01080001 0x010C0004 0x01100003 0x010C0006 0x01100005 **AB-1600GE** 0x01080008 0x0110000C 0x01100010	Mono8 Mono 10 Packed Mono10 Mono12 Packed Mono12 BAYGR8B BAYGR10 BAYGR12	Mono8 for AM-1600GE / BAYRG8 for AB-1600GE
0xA414	Frame Skipping Ratio	R W	4	0=3.04 fps 1=1.52 fps 2=0.76 fps 3=0.38 fps		0
0xA418	Payload Length register	R	4		Number of bytes in a frame	
0xA41C	OB Trans Mode	R W	4	0= OFF 1= ON		0
0xA500	ROI Mode	R W	4	1 to 5	ROI End Position 1-5	1
0xA504	ROI1 Size X	R W	4	24 to 4872	Width	W.Max
0xA508	ROI1 Size Y	R W	4	8 to 3248	Height	H.Max
0xA50C	ROI1 Offset X	R W	4	0 to 4864	Horizontal offset	0
0xA510	ROI1 Offset Y	R W	4	0 to 3240	Vertical offset	0
0xA514	ROI2 Size X	R W	4	24 to 4872	Width 2	W.Max
0xA518	ROI 2 Size Y	R W	4	8 to 3248	Height 2	H.Max
0xA51C	ROI 2 Offset X	R W	4	0 to 4864	Offset X2	0
0xA520	ROI 2 Offset Y	R W	4	0 to 3240	Offset Y2	0
0xA524	ROI 3 Size X	R W	4	24 to 4872	Width 3	W.Max
0xA528	ROI 3 Size Y	R W	4	8 to 3248	Height 3	H.Max
0xA52C	ROI 3 Offset X	R W	4	0 to 4864	Offset X3	0
0xA530	ROI 3 Offset Y	R W	4	0 to 3240	Offset Y3	0
0xA534	ROI 4 Size X	R W	4	24 to 4872	Width 4	W.Max
0xA538	ROI 4 Size Y	R W	4	8 to 3248	Height 4	H.Max
0xA53C	ROI 4 Offset X	R W	4	0 to 4864	Offset X4	0
0xA540	ROI 4 Offset Y	R W	4	0 to 3240	Offset Y4	0

Address	Function	Read/ Write	Size	Value / Range of value	Description	Default value
0xA544	ROI 5 Size X	R W	4	24 to 4872	Width 5	W.Max
0xA548	ROI 5 Size Y	R W	4	8 to 3248	Height 2	H.Max
0xA54C	ROI 5 Offset X	R W	4	0 to 4864	Offset X 5	0
0xA550	ROI 5 Offset Y	R W	4	0 to 3240	Offset Y 5	0
0xA600	User Output 0	R W	4	31bit=User out o 30bit=User out 1 29bit=User out 2 28bit=User out 3	Software trigger	0
0xA604	Acquisition Control	R W	4	0=Stop , 1=Start		0
0xA610	Event ON/OFF register	R W	4	Bit31:GEV_EVENT_TRIGGER		0
				Bit30:GEV_EVENT_START_OF_EXPOSURE		0
				Bit29:GEV_EVENT_END_OF_EXPOSURE		0
				Bit28:GEV_EVENT_START_OF_TRANSFER		0
				Bit27:GEV_EVENT_END_OF_TRANSFER		0
				Bit26:GEV_EVENT_TRIGGER ERROR		0
				Bit25:Line 1 Active(TTL out1)		0
				Bit24:Line 2 Active (TTL out 2)		0
				Bit23:Line 3 Active(TTL out 3)		0
				Bit22*Line 4 Active (TTLout4)		0
0xA640	Device Reset	w	4	0=OFF 1=Reset		0

GPIO Registers:

0xB000	Counter Clock source	R W	4	0x01	Pixel Clock	0
0xB004	Counter Divide by Value	R W	4	0x000 0x001 0x002 | 0xFFF	Bypass Divide by 2 Divide by 3 | Divide by 4096	0
0xB008	Length Counter 0	R W	4	0x00001 to 0xFFFFF	Defines the length of the counter	1
0xB00C	Start point Counter 0	R W	4	0x00001 to 0xFFFFF	Defines the starting point of the counter	0
0xB010	Repeat Count 0	R W	4	0x00: infinite 0x01: 1 time | 0xFF: 255 times	Defines the number of repeats (loops)	0

Address	Function	Read/ Write	Size	Value / Range of value	Description	Default value
0xB014	End point Counter 0	R W	4	0x00001 to 0xFFFFF	Defines the end point of the counter	1
0xB018	Counter 0 Clear	R W	4	0 1 2 4 8	Free Run High Level Clear Low Level Clear Rising Edge Clear Falling Edge Clear	0
0xB01C	Length Counter 1	R W	4	0x00001 to 0xFFFFF	Counter length	1
0xB020	Start point Counter 1	R W	4	0x00001 to 0xFFFFF	Start Point	0
0xB024	Repeat Count 1	R W	4	0x00: infinite 0x01: 1 time | 0xFF: 255 times	Repeat Count	0
0xB028	End point Counter 1	R W	4	0x00001 to 0xFFFFF	End point	1
0xB02C	Counter 1 Clear	R W	4	0 1 2 4 8	Free Run High Level Clear Low Level Clear Rising Edge Clear Falling Edge Clear	0
0xB060	Selector CAMERA TRIGGER 0	R W	4	GPIO Selector: **Line Source** 0x00:CAMERA LVAL IN 0x02:CAMERA FVAL IN 0x03:CAMERA EEN IN 0x04:OPT IN 1 0x05:OPT IN 2 0x06:TTL IN 1 0x07:LVDS IN 1 0x0C:SOFT TRIG 0 0x0D:SOFT TRIG 1 0x0E:SOFT TRIG 2 0x0F:SOFT TRIG 3 0x10:Pulse Gen. 0 0x11:Pulse Gen. 1 **Line Selector** 0x00:Camera trigger 0 0x01:Camera trigger 1 0x04:TTL OUT 1 0x05:TTL OUT 2 0x06:OPT OUT 1 0x07:OPT OUT 2 0x0C:Pulse Gen. 0 0x0D:Pulse Gen. 1 0x10:Time Stamp reset 0x11:Sequence Table reset Add 0x80 will result in low active output.	For Camera Trigger	127
0xB064	Selector CAMERA TRIGGER 1	R W	4		For Delayed Trigger	
0xB070	Selector GPIO PORT 1	R W	4		TTL out 1	
0xB074	Selector GPIO PORT 2	R W	4		TTL out 2	
0xB078	Selector GPIO PORT 3	R W	4		Optical out 1	
0xB07C	Selector GPIO PORT 4	R W	4		Optical out 2	
0xB090	Selector Pulse Generator 0	R W	4			
0xB094	Selector Pulse Generator 1	R W	4			
0xB0A0	Selector Time Stamp Reset	R W	4			
0xB0A4	Selector Sequence Table Reset	R W	4			

10.External Appearance and Dimensions

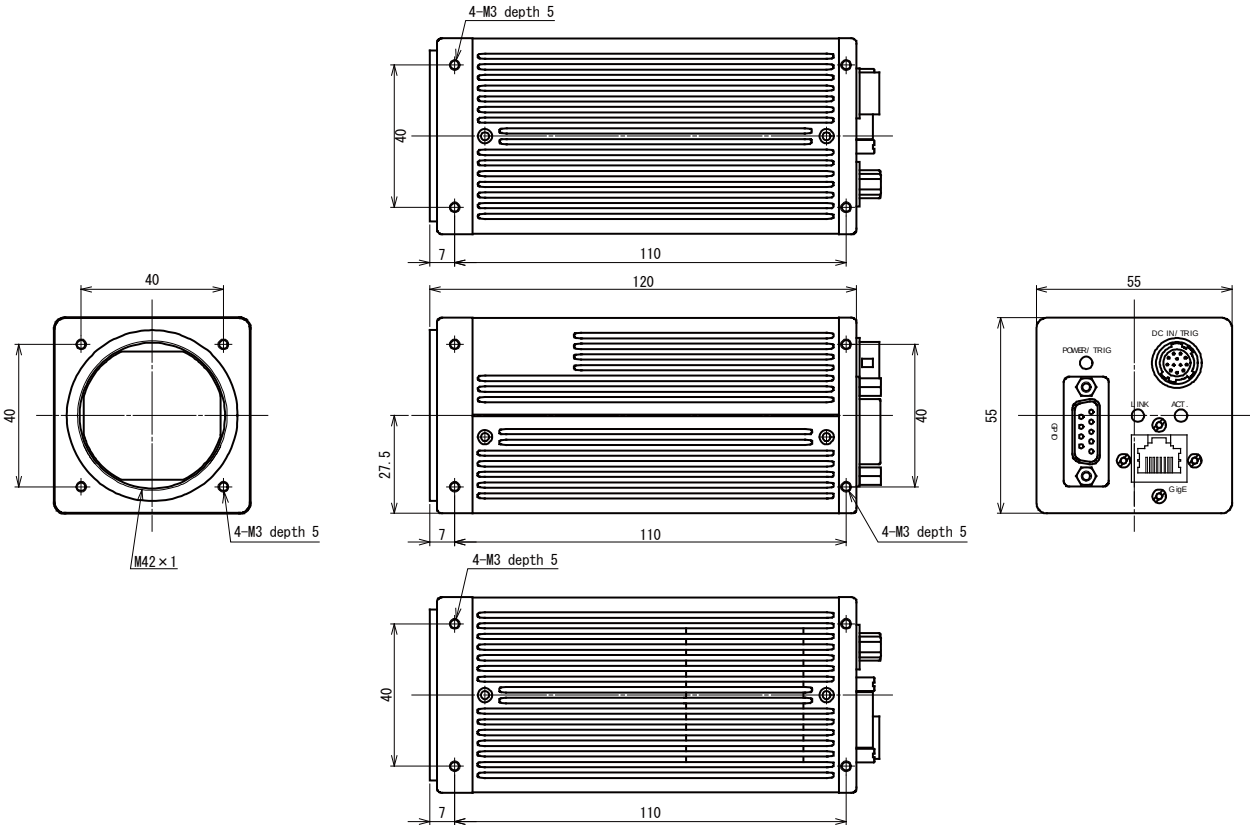


Fig. 29 Outline View (AM/AB-1600GE-P)

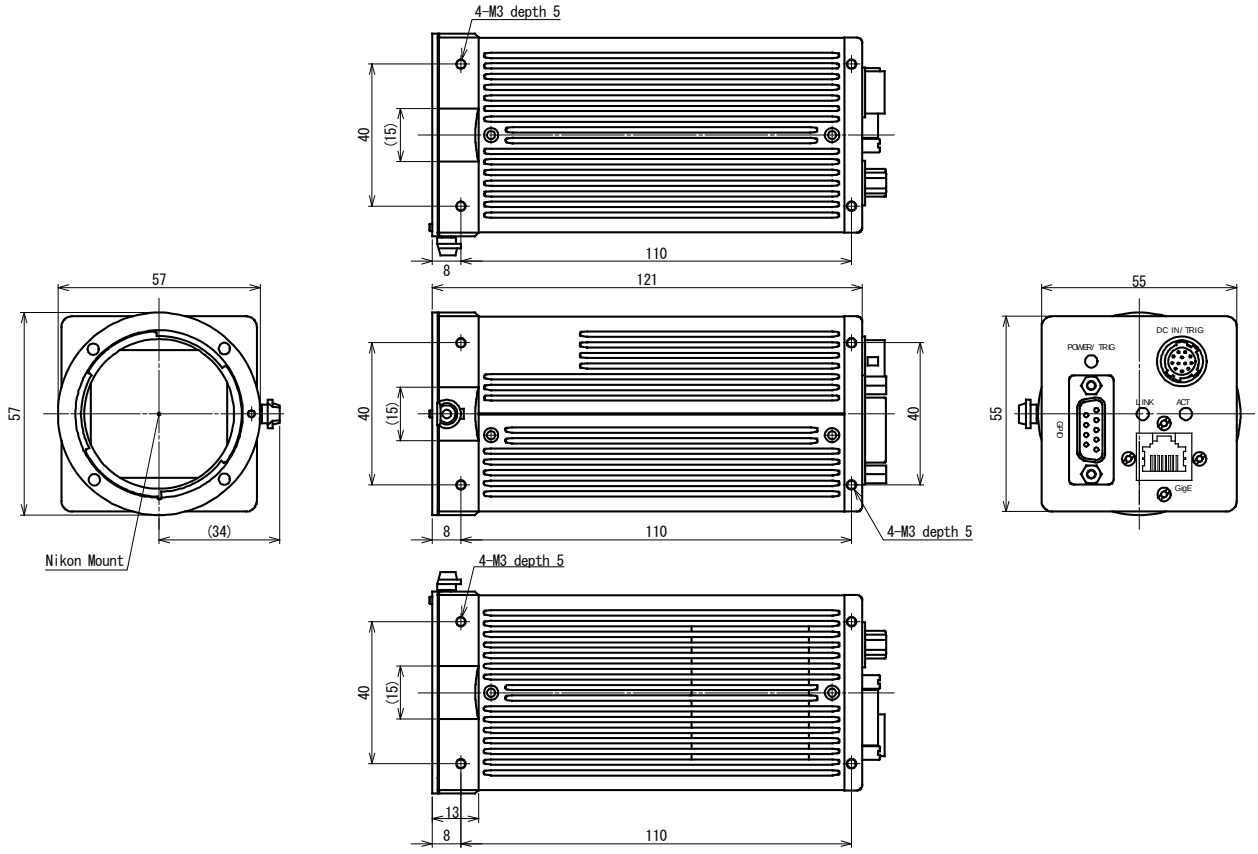


Fig.30 Outline View (AM/AB-1600GE-F)

11.Specifications

11.1 Spectral response

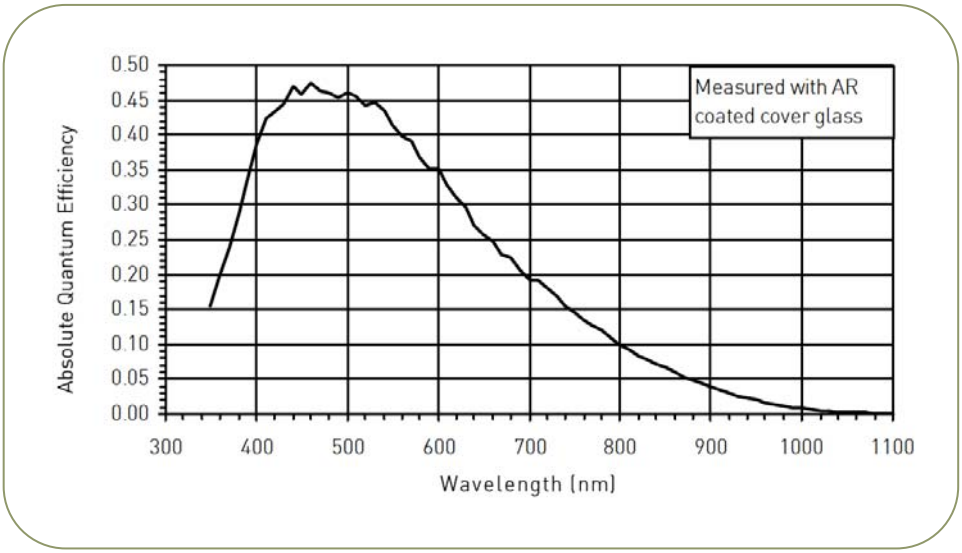


Fig. 31 Spectral response for AM-1600GE

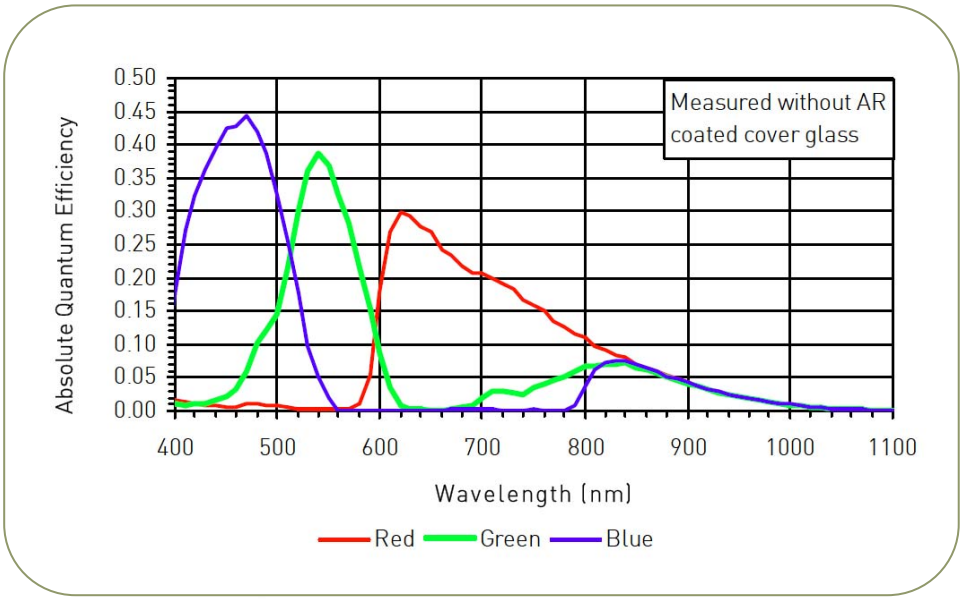


Fig.32 Spectral response for AB-1600GE

11.2 Specification table

Specifications	AM-1600GE	AB-1600GE
Scanning system	Progressive scan	
Frame rate full frame	3.04 frames/sec. Progressive (3327 lines/frame)	
Pixel clock	30 MHz	
Line frequency	10.135 kHz (1H = 98.66 μs) (2960 pixel clock/line L ch and 2960 pixel clock / line R ch)	
CCD sensor	43.3mm diagonal Monochrome KAI-16000-AXA	43.3mm diagonal Bayer Color KAI-16000-CXA
Sensing area	36.05 (h) x 24.035 (v) mm 43.3mm diagonal	
Cell size	7.4 (h) x 7.4 (v) μm	
Active pixels	4872 (h) x3248 (v)	
Pixels in video output. Full scan 1/2 partial scan 1/4 partial scan Variable partial scan	4872 (h) x 3248 (v) 3.04 fps. H = 10.135 kHz 4872(h) x 1372 (v) 5.51 fps H= 10.135 kHz 4872 (h) x 1028 (v) 9.25 fps. H = 10.135 kHz Start line from 1 to 2448 by 1 line unit for AM-1600GE, 2 lines units for AB-1600GE , height(lines) from 800 to 3248	
Vertical binning mode	2x (5.63 fps)	n/a
Sensor sensitivity	Output : 30μV/e Saturation: 30,000 electrons	
Sensitivity on sensor (minimum)	0.02 Lux (Max. gain, Shutter OFF, 50% video)	0.35 Lux (Max. gain, Shutter OFF,50% Green, w/IR cut filter)
S/N ratio	More than 56 dB (0dB gain)	More than 56 dB (Green, 0dB gain)
Digital video output	GigE Vision Compliant Mono8,Mono10,Mono10_Packed Mono 12, Mono12_Packed	GigE Vision Compliant BAyGR8, BAYGR10 BAYGR12
White balance	n/a	Manual/One push
Gain	Manual Master gain: -3dB to +12dB Individual gain : -6dB to +6dB (AB-1600GE only) AGC : -3 to +12 dB	
Black level	Default setting: 32LSB(10 bits output), Range : 0 LSB to 128 LSB	
Gamma/Knee	LUT (γ=1.0(OFF), γ=0.45(ON))	
Blemish correction	ON / OFF, Calibration	n/a
Shading compensation	Provided	n/a
L/R channel balance	provided	
Test pattern generator	Provided	
Synchronization	Internal X-tal	
GPIO Module Input/output switch Clock generator (One) Pulse generators (Two)	Configurable 13-in / 10-out switch 12-bit counter based on Pixel clock 19-bit counter programmable for length, start point, stop point, repeat	
Hardware trigger modes	Edge Pre-Select , Pulse Width Control, Frame Delay and Sequence	
OB area transfer mode	ON / OFF	
Event message	Exposure start, Exposure end, Trigger IN, Video start, Video end	

Specifications	AM-1600GE	AB-1600GE
Electronic Shutter Programmable exposure Exposure Time (Abs) Exposure Auto continuous GPIO plus Pulse Width	3(296µs) to 3327 L (328ms) in 1L steps µsec – user definable. Same range as PE 100L to 3327L (1/101.35 sec to 1/3 sec) max. 2 sec (Can be set by 100µs unit or Pixel Clock unit)	
Control interface	Register based. GigE Vision / GenICam compliant	
Functions controlled via GigE Vision Interface	Shutter, Gain, Black Level, Trigger mode, Read out mode, GPIO setup ,ROI (GenICam mandatory functions)	
GigE Vision Streaming Control	Packet size, Delayed (Frame) read-out, inter-packet delay Jumbo Frame can be set at max. 16020 , Default packet size is 1476 Byte.	
Indicators on rear panel	Power, Hardware trigger, GigE Link, GigE activity	
Operating temperature	-5°C to +45°C	
Humidity	20 – 80% non-condensing	
Storage temp/humidity	-25°C to +60°C/20% to80 % non-condensing	
Vibration	10G (20Hz to 200Hz, XYZ)	
Shock	70G	
Regulatory	CE (EN61000-6-2 and EN61000-6-3), FCC part 15 class B, RoHS, WEEE	
Power	12V DC ± 10%. 7.5 w (typical in continuous mode) 9.6 W (max. in 800 lines partial scan)	
Lens mount	Universal P mount , Rear protrusion must be less than 11.0mm or Nikon F mount , Rear protrusion must be less than 12.0mm	
Flange back	Universal P mount : 45.5mm, Tolerance 0 to -0.05mm Nikon F mount : 46.5mm, Tolerance 0 to -0.05mm	
Dimensions	55 x 55 x 120 mm (W x H x D) (excluding surface projection)	
Weight	430 g	430 g

Note: Above specifications are subject to change without notice
In order to get specified performance, approx. 30 minutes of pre-heating is required.

12.Appendix

12.1. Precautions

Personnel not trained in dealing with similar electronic devices should not service this camera. The camera contains components sensitive to electrostatic discharge. The handling of these devices should follow the requirements of electrostatic sensitive components.
Do not attempt to disassemble this camera.
Do not expose this camera to rain or moisture.
Do not face this camera towards the sun, extreme bright light or light reflecting objects, including laser sources.
When this camera is not in use, put the supplied lens cap on the lens mount.
Handle this camera with the maximum care.
Operate this camera only from the type of power source indicated on the camera.
Remove power from the camera during any modification work, such as changes of jumper and switch settings.

12.2. Typical Sensor Characteristics

The following effects may be observed on the video monitor screen. They do not indicate any fault of the camera, but do associate with typical sensor characteristics.

V. Aliasing

When the camera captures stripes, straight lines or similar sharp patterns, jagged image on the monitor may appear.

Blemishes

All cameras are shipped without visible image sensor blemishes.
Over time some pixel defects can occur. This does not have a practical effect on the operation of the camera. These will show up as white spots (blemishes).
Exposure to cosmic rays can cause blemishes to appear on the image sensor. Please take care to avoid exposure to cosmic rays during transportation and storage. It is recommended using sea shipment instead of air transportation flight in order to limit the influence of cosmic rays on the camera.
Pixel defects/blemishes may also emerge due to prolonged operation at elevated ambient temperature, due to high gain setting or during long time exposure. It is therefore recommended to operate the camera within its specifications.

Patterned Noise

When the sensor captures a dark object at high temperature or is used for long time integration, fixed pattern noise may appear in the image.

12.3. Caution when mounting a lens on the camera

When mounting a lens on the camera dusts particles in the air may settle on the surface of the lens or the image sensor of the camera. It is therefore important to keep the protective caps on the lens and on the camera until the lens is mounted. Point the lens mount of the camera downward to prevent dust particles from landing on the optical surfaces of the camera. This work should be done in a dust free environment. Do not touch any of the optical surfaces of the camera or the lens.

12.4. Exportation

When exporting this product, please follow the export regulation of your own country.

12.5. References

1. This manual for AM-1600GE / AB-1600GE can be downloaded from www.jai.com
2. Datasheet for AM-1600GE / AB-1600GE can be downloaded from www.jai.com
3. Camera control software can be downloaded from www.jai.com
4. Specifications for the CCD sensor Kodak KAI-16000-AXA and KAI-16000-CXA can be found on www.jai.com

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Changes history

Month/Year	Revision	Contents
	1.0	New issue

User's Record

Camera type: **AM-1600GE / AB-1600GE**

Revision: ……..

Serial No. ……..

Firmware version. ……..

For camera revision history, please contact your local JAI distributor.

User's Mode Settings.

User's Modifications.

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